Report No. CG-D-19-93

APPLICATION OF TILTROTOR TECHNOLOGY TO U.S. COAST GUARD MISSIONS

J. Casler

T. Cooney

D. Hall

A. Roe

J. Whitacker

Veda, Inc.
300 Exploration
Lexington Park, MD 20653

FINAL REPORT

JULY 1993

This document is available to the U.S. public through the
National Technical Information Service, Springfield, Virginia 22161

Prepared for:

U.S. COAST GUARD
Research and Development Center
1082 Shennecossett Road
Groton, Connecticut 06340-6096

and

U.S. Department of Transportation
United States Coast Guard
Office of Engineering, Logistics, and Development
Washington, D.C. 20593-0001

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

The contents of this report reflect the views of the Coast Guard Research & Development Center. This report does not constitute a standard, specification, or regulation.

W. E. Colburn, Jr.
Technical Director, Acting
United States Coast Guard
Research & Development Center
1082 Shennecossett Road
Groton, CT 06340-6096

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CG-D-19-93		

4. Title and Subtitle APPLICATION OF TILTROTOR TECHNOLOGY TO U.S. COAST GUARD MISSIONS	5. Report Date September 1993
	6. Performing Organization Code
	8. Performing Organization Report No. R&DC 15/93
7. Author(s) J. Casler, T. Cooney, D. Hall, A.Roe, J. Whitacker	
9. Performing Agency Name and Address Veda Incorporated 300 Exploration Lexington Park, MD 20653	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. N00421-92-D-0160
12. Sponsoring Agency Name and Address U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, Connecticut 06340-6096 Department of Transportation U.S. Coast Guard Office of Engineering, Logistics, and Development Washington, D.C. 20593-0001	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

CG R&D Center Project Officers; LCDR David C. Spillman (203) 441-2696
LT John G. Hornbuckle

16. Abstract

The Congress of the United States has directed the U.S. Coast Guard to determine the potential offered by tiltrotor aircraft technology, more specifically the V-22, for three Coast Guard functions; Search and Rescue (SAR), Law Enforcement/Maritime Interdiction (LE/MI), and Marine Environmental Protection (MEP). This study examines potential employment scenarios of the V-22 in the identified mission components, measures the operational effectiveness of the V-22, and determines the manpower and operating costs associated with those employments. The effectiveness and costs of the V-22 are compared with the effectiveness and costs of the four aircraft models which the USCG expects to employ in 1998. These four aircraft are the HH-60J, the HH-65A, the HC-130H, and the HU-25A/B/C and represent the baseline aircraft alternatives for this analysis.

In general, the V-22 offers some distinct advantages over the baseline helicopter fleet due to its ability to cruise at fixed-wing airspeeds, to operate at greater distances and to transport more cargo/personnel than either the HH-65 or the HH-60. In addition, the fixed-wing capabilities of the V-22 are, for the most part, equal to or slightly better than the HU-25. The greater speed of the HU-25 is generally offset by the greater operational radius and the mission flexibility provided by the dual role (helicopter and fixed-wing) capacity of the V-22. These advantages become marginal, however, when examined in the context of the historical USCG employment of aircraft in SAR, LE/MI, and MEP. The study also indicates that tiltrotor technology would substantially increase USCG operating costs over current aircraft while having a negligible effect on manpower costs of the baseline fleet.

17. Key Words		18. Distribution Statement
V-22	Tiltrotor Technology	Document is available to the U.S. public through the National Technical Information Service Springfield, Virginia 22161
SAR	Operational Effectiveness	
MEP	Operating Costs	
LE/MI		

19. Security Classif. (of this report)	20. SECURITY CLASSIF. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED		

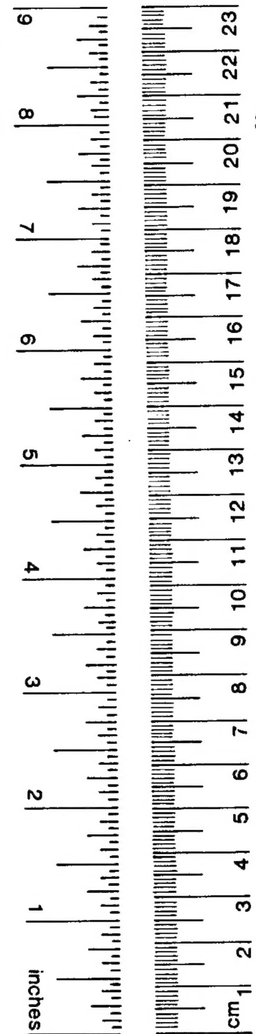
Form DOT F 1700.7 (8/72) **Reproduction of form and completed page is authorized.**

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

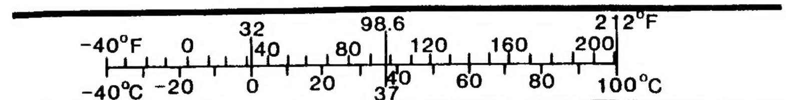


TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

AM	Amplitude Modulation
AUW	Airframe Unit Weight
BHC	Boeing Helicopter Company
BHT	Bell Helicopter Textron
BOS	Base Operating and Support
CASP	Computer Assisted Search Planning
CER	Cost Estimating Relationship
CGAS	Coast Guard Air Station
COEA	Cost and Operating Effectiveness Analysis
CY	Calendar Year
DEA	Drug Enforcement Agency
deg	degree
DoD	Department of Defense
EEZ	Exclusive Economic Zone
EMD	Engineering and Manufacturing Development
FLIR	Forward Looking Infrared
FM	Frequency Modulation
FSD	Full Scale Development
FY	Fiscal Year
GHSR-O	Government Hourly Standard Rate-Outside
GPS	Global Positioning System
HF	High Frequency
HIFR	Helicopter In-Flight Refueling
IDA	Institute for Defense Analysis
IFF	Identification Friend or Foe
ILS	Instrument Landing System
IOC	Initial Operational Capability
JSAFT	Joint Service Auxiliary Ferry Tank
JSOR	Joint Services Operating Requirement
JVX	Joint Services Vertical Lift Aircraft
LE	Law Enforcement
LE/MI	Law Enforcement/Maritime Interdiction
LEDET	Law Enforcement DETachment

LRS	Long Range Search or Surveillance
MAA	Mission Area Analysis
MB	Marker Beacon
MEP	Marine Environmental Protection
MLR	Medium Lift Replacement
MOE	Measure of Effectiveness
MOP	Measure of Performance
MRA	Medium Range Apprehension
MRD	Medium Range Detection
MRI	Medium Range Intercept
MRR	Medium Range Recovery
MRS	Medium Range Search or Surveillance
MSO	Marine Safety Office
NATOPS	Naval Aviation Training and Operating Procedures Standardization
NAVAIRSYSCOM	Naval Air Systems Command
NSF	National Strike Force
NVG	Night Vision Goggles
O&S	Operating and Support
OEI	One Engine Inoperative
OP	Aircraft Operating Cost
OPBAT	Operation Bahamas and Turks
ORD	Operational Requirements Document
OWOCRS	Open Water Oil Containment Recovery System
R&M	Reliability and Maintainability
RCC	Rescue Coordination Center
RNAV	Area Navigation
RRI	Response Recovery Inventory
RS	Rescue Swimmer
SAR	Search and Rescue
SARMIS	SAR Management Information System
shp	shaft horsepower
SLAR	Side Looking Airborne Radar
SRR	Short Range Recovery
SRU	Search and Rescue Unit
STO	Short Take-off
TACAN	TACtical Air Navigation

TOS	Time On Station
UHF	Ultra High Frequency
USAF	United States Air Force
USCG	United States Coast Guard
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio
VSTOL	Vertical or Short Take Off and Landing
VTO	Vertical Take-Off
$M	Millions of dollars

Section 1.0
Executive Summary

The Congress of the United States has directed the U.S. Coast Guard to determine the potential offered by tiltrotor aircraft technology, more specifically the V-22, for three Coast Guard functions. In order to answer these questions, this study examines potential employment scenarios of the V-22 in the identified mission components, measures the operational effectiveness of the V-22 in those scenarios, and determines the manpower and operating costs associated with those employments. In these mission component scenarios, the effectiveness and costs of the V-22 are compared with the effectiveness and costs of the four aircraft models which the Coast Guard expects to employ in those mission components in the year 1998. These four platforms are the HH-60J Jayhawk, the HH-65A Dolphin, the HC-130H Hercules, and the HU- 25A/B/C Guardian and represent the baseline aircraft alternatives for this analysis.

In general, the tiltrotor technology as represented by the V-22 offers some distinct advantages over the baseline helicopter fleet due to its ability to cruise at fixed-wing airspeeds, to operate at greater distances and to transport more cargo/personnel than either the HH-65 or the HH-60. In addition, the fixed-wing capabilities of the V-22 are, for the most part, equal to or slightly better than the HU-25. The greater speed of the HU-25 is generally offset by the greater operational radius and the mission flexibility provided by the dual role (helicopter and fixed-wing) capacity of the V-22.

In the Search and Rescue (SAR) function, the tiltrotor technology exemplified by the V-22 appeared to offer a set of characteristics that could be applied to the mission. The helicopter mode coupled with the speed and range of a fixed-wing aircraft could extend the full SAR mission performance beyond the range limits of the baseline helicopter force. The response standard of two hours could be met at distances double the HH-60 range and only slightly less than the range of the HU-25. The HC-130H area search capability far exceeded all other alternatives. The V-22 with a Joint Service Auxiliary Fuel Tank (JSAFT) provided essentially the same search capability as the HU-25. The passenger capacity of the V-22 provides the capability to address major disasters at a significant distance from the launch point when compared to the helicopter alternatives. In comparison to the fixed-wing aircraft, the V-22 possesses the ability to extract victims which these alternatives lack. Both V-22 configurations enabled the hoisting of victims at long ranges without requiring additional aircraft specifically to effect the extraction. However, while long distance and large passenger capacity in themselves are significant advantages, the utility of these features may be marginal when examined in the context of the historical SAR data

base. The data base indicates that over 90% of all SAR missions occur within 37 km of the coast, and that 76% of those involving potential loss of life or property occur within 185 km of a Coast Guard Air Station (CGAS) and 95% within 556 km of a CGAS. In addition, in the incidents involving extraction of victims, 90% of the incidents involved 4 or fewer people. The principal advantage derived from the V-22 capabilities appear to apply to 5-10% of the total number of incidents. Therefore, the results of this study indicate that the applications of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of search and rescue at sea offers a marginal increase in effectiveness over the current baseline systems. This conclusion is contingent on whether future flight testing demonstrates a viable operational capability of hoist extraction of personnel from open water.

The scenario for the Law Enforcement mission area focused on drug interdiction. This function can be further divided into interdiction of illegal drugs being transported by air or interdiction of illegal drugs being transported by sea. The latter case was chosen as being more representative of the Coast Guard's major role in this area. The role of aircraft in this mission is limited to searching for the seaborne drug carrier and tracking the vessel until a Coast Guard cutter can be vectored into the area. The greater fuel capacity and higher speeds of the V-22 results in advantages over the helicopter fleet. However, when utilized, deployment of HH-60 and HH-65 aircraft aboard cutters would mitigate the extent of the V-22 operational effectiveness advantage. Once the suspected drug boat has been located, the higher cruise speed of the HU-25 results in a quicker intercept. This advantage is marginally important, however, due to the slow speed of the target. The V-22 capability of conversion from fixed-wing to rotary-wing flight gives it an advantage over the HU-25 and the HC-130H in maintaining track of slower moving boat traffic without significantly reducing time on station. The results of this study indicate that the application of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of enforcement of the laws of the United States, especially with the respect to maritime drug interdiction offers an operational effectiveness equivalent to several of the baseline systems.

In the Marine Environmental Protection (MEP) function, the scenario chosen is the incident response scenario focused on an oil spill. This accounted for the greatest percentage of incident responses by the National Strike Force in 1992. The primary functions of aircraft in this mission are the movement of equipment to the incident and monitoring/reporting on the spill area and its characteristics until the clean-up process can commence. The equipment associated with oil spill containment is large in size, weight, and quantity. Several items of equipment, as currently packaged, primarily related to the Open Water Oil Containment Recovery System (OWOCRS) and Vessel of Opportunity Skimming System (VOSS), either do not fit the V-22 cabin space or exceed

the internal or external load capacity of the V-22. While determination of the feasibility of repackaging these items into V-22 compatible loads is beyond the scope of this study, the margins by which the aircraft dimensions or weights are exceeded suggest that repackaging may be possible. The significant cargo capacity and range of the HC-130H dominates this scenario. The HC-130H is the most effective aircraft for carrying the equipment from the strike force location to the staging area due to its range and the size of the cargo bay. The V-22 is the most effective vehicle for transporting the equipment to the spill site. In the movement of the spill containment equipment from the staging area to the spill site, the normal mode of transport is tractor-trailer. The speed differential of the V-22 relative to overland transportation enables more rapid transportation of the equipment by V-22 despite only fewer loads being required to move the equipment overland. The possible advantage of using the V-22 to transport equipment directly from its initial location at the strike force to the spill site versus using an intermediate staging area as required by the HC-130H case was also examined. For these cases, the results appear to be dominated by the time saved using the HC-130H; and therefore, there appears to be no advantage in using the V-22. In the monitor phase, the fuel capacity of the V-22 enables it to equal or exceed the capabilities of all other aircraft except the HC-130H. Within the scope of this study, the application of tiltrotor technology, as represented by the V-22, in the Coast Guard Marine Environmental Program offers an operational effectiveness equivalent to several of the baseline systems in minimizing of the damage caused by oil or other hazardous substances spills in the waters of the United States. This conclusion is contingent on whether repackaging of the MEP equipment for transportation aboard the V-22 is possible.

The cost of operating the V-22 is compared to the baseline fixed-wing and helicopter aircraft using the outside government hourly standard rates. The V-22 is the most expensive alternative to operate. It is approximately 1.5 times as expensive to operate as the baseline aircraft alternatives. However, the manpower requirements for the V-22 are less than the manpower required for the HH-60 or the HC-130 but greater than the HU-25 and HH-65 requirements. Therefore, the results of this study indicate that tiltrotor technology, as represented by the V-22, would have the effect of substantially increasing Coast Guard operating costs over current baseline aircraft while having a negligible effect on manpower costs across the current baseline fleet.

Section 2.0
Introduction

2.1 Background

The Coast Guard has been traditionally assigned the primary roles of maritime search and rescue (SAR), maritime safety, maritime law enforcement, national security, and marine environmental protection. In the accomplishment of those roles, the Coast Guard uses its aviation resources to meet four general demands. These are: Long Range Search or Surveillance (LRS), Medium Range Search or Surveillance (MRS), Medium Range Recovery (MRR), and Short Range Recovery (SRR). Additionally, more specialized demands arise for which aviation assets are used. The special use demand categories relevant to this study include Medium Range Intercept (MRI), Medium Range Apprehension (MRA), and Medium Range Detection (MRD). This wide range of Coast Guard roles is accomplished in a correspondingly wide variety of geographic, environmental, and operational conditions. Consequently, operational flexibility is the rule for Coast Guard systems in meeting these multimission demands. Review of the expirations of the 20-year service life planned for the four primary Coast Guard aircraft, i.e., HH-60J, HH-65A, HU-25A/B/C, and HC-130H, shows that the HU-25 fleet will achieve 20 years service as early as 2001 and the HH-65A in 2004. Determination of the requirements and composition for the Coast Guard aviation fleet beyond 2000 certainly must consider the multimission demands described above and must emphasize multimission effectiveness, efficiency, reliability, and affordability. The nature of the Coast Guard missions is, to some extent, similar to multimission demands which exist for the Department of Defense. These missions are articulated in the Joint Services Vertical Lift Aircraft (JVX) Operating Requirement (JSOR) which identifies the operational requirement upon which the V-22 aircraft has been developed. The V-22 aircraft with its dual modes of operation, i.e., helicopter and fixed-wing, has the potential to meet the multimission requirements of Coast Guard aviation systems. To that end, Congress directed the U.S. Coast Guard to conduct a study in Fiscal Year 1993 of the application of the V-22 Osprey tiltrotor technology to three Coast Guard functions, i.e., Search and Rescue, Maritime Law Enforcement (with emphasis on Drug Interdiction), and Marine Environmental Protection.

2.2 Purpose of Analysis

The purpose of this analysis is to evaluate the potential offered by tiltrotor aircraft technology for the Coast Guard mission components of Search and Rescue, Maritime Law Enforcement, and Marine Environmental Protection. The study evaluates the operational

effectiveness and the manpower and operating costs of the V-22 Osprey tiltrotor aircraft compared to the baseline air platforms currently used by the Coast Guard.

2.3 Specific Tasking

The specific tasks which are addressed by this study are:

1. Evaluate the application of tiltrotor technology to Coast Guard mission components including:

    a. Search and rescue at sea; and
    b. The enforcement of laws of the United States especially with respect to drug interdiction.

2. Determine whether use of tiltrotor technology in the Coast Guard Marine Environmental Protection Program would minimize the damage caused by oil or other hazardous substances spills in the waters of the United States.

3. Determine what effect the technology would have on Coast Guard manpower and operating costs, compared to those costs associated with technology currently used by the Coast Guard.

Section 3.0
Analysis Methodology

3.1 Methodology Overview

For the identified Coast Guard functions, the effectiveness of the V-22 is evaluated against the effectiveness of the baseline aircraft that currently perform each mission component. For each mission component, the analysis proceeded along the following series of steps:

1. Define the functional objectives of the mission component.
2. Develop scenarios for aircraft employment in the mission component.
3. Develop Measures of Effectiveness (MOE) for Coast Guard validation.
4. Analyze the operational effectiveness of the V-22 and the baseline platforms for each mission component.
5. Analyze the manpower and operating cost of the V-22 and baseline platforms.

The general approach was to obtain sufficient information to define the mission components of interest in terms of V-22 employment and MOEs through existing documents, briefings, and interviews. Through research of existing documents and past studies, the analytical similarities which enabled comparisons of the V-22 with the baseline aircraft in terms of operational effectiveness, manpower, and operating costs were extracted.

3.1.1 Missions

Congressional language specifically identified the Search and Rescue, Maritime Law Enforcement (with emphasis on Drug Interdiction), and Marine Environmental Protection functions for the potential application of tiltrotor technology. Currently, few, if any, formal mission area analyses (MAA) provide sufficient description of the various missions. Therefore, an independent analysis, albeit cursory, of each mission component was undertaken to provide a common basis for further study. The analytical efforts were structured to describe, as much as possible, the missions in terms of quantifiable requirements, i.e., MOEs and Measures of Performance (MOPs). Interviews were conducted at Coast Guard Headquarters, Washington D.C., Coast Guard Air Station (CGAS) Elizabeth City, Elizabeth City, North Carolina, and CGAS Miami, Miami, Florida to further enhance the understanding of the mission components and to focus on the critical elements of analysis for each mission component.

3.1.2 Scenario and Threat

This analysis required the development of scenarios for employing the V-22 aircraft in Coast Guard functions. Time constraints limited the analysis to a single scenario for each mission component. Each scenario was chosen to be representative of the conditions envisioned for that specific mission component. A baseline set of assumptions was established for each scenario and a limited sensitivity analysis regarding those assumptions was conducted. Although threat capabilities were originally envisioned to be relevant for the Law Enforcement function, further discussions at the United States Coast Guard Research and Development Center, Groton, Connecticut indicated that a threat analysis was not necessary.

3.1.3 Measures of Effectiveness (MOE) / Measures of Performance (MOP)

Each mission component under evaluation was divided into subtasks called functional objectives. These functional objectives were subdivided into the measurable elements for each objective. The measurable elements were examined to determine how well the aircraft employed in the mission component were performing the function. These measurable elements, i.e., MOE and MOP, either taken singularly or in combination, provided the basis for distinguishing among the alternatives. This process is depicted in Figure 3-1. The analysis measures were approved by the Coast Guard prior to comparison of the operational effectiveness of the V-22 and baseline aircraft in the mission scenarios.

3.1.4 Operational Effectiveness Analysis

For each scenario, a matrix was generated which charted the performance of tiltrotor technology as represented by the V-22 and the current baseline aircraft in each measurable area. This matrix also highlighted areas where specific aircraft or combinations of aircraft outperform the others in each scenario.

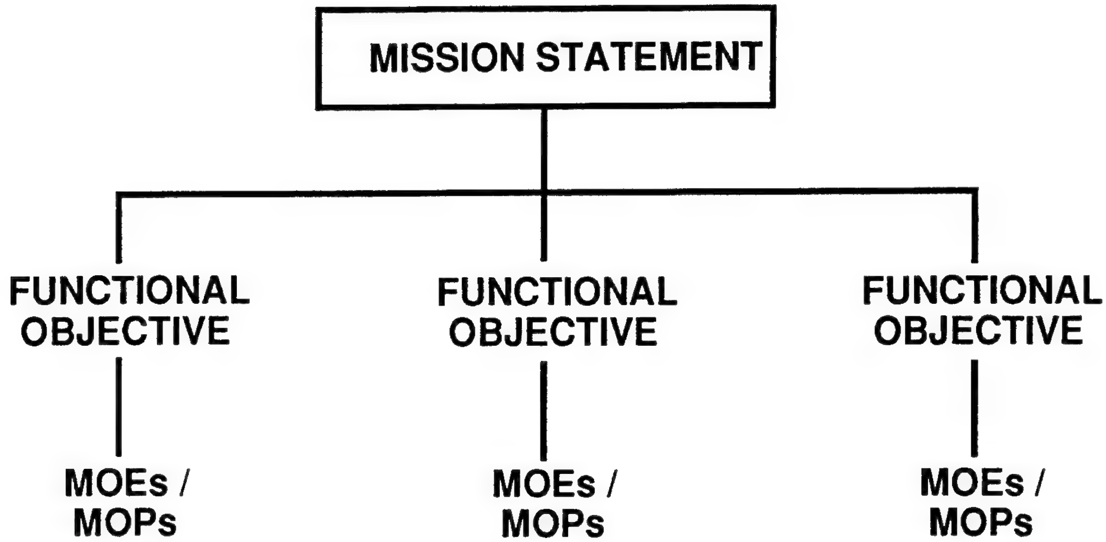


Figure 3-1 - Scenario Development Process Analysis

3.1.5 Manpower and Operating Cost Analysis

The data and outputs from the V-22 Operating and Support (O&S) estimate prepared for Navy and Marine Corps use (Air Force did not develop an O&S estimate) and from the existing Coast Guard O&S estimates for the baseline aircraft were reviewed and analyzed at the lowest level of input detail available. An analogous estimate was prepared using the relationship of the H-60 use in the Navy to projected use of a Navy MV-22. This relationship was then applied to the Coast Guard HH-60J to project operating costs for the V-22 within the Coast Guard. Manpower projections were accomplished in a similar manner from a generic staffing pattern provided by the Coast Guard.

3.2 Constraints

Cost and Operational Effectiveness Analyses (COEA) for major weapon systems typically have the benefit of reasonably well-established MAAs, are focused on a small number of missions areas (usually one or two), and frequently require a year or more of effort. The time available for this study imposed substantial constraints and essentially precluded any detailed modeling effort. Consequently, the study was limited to research of available documents and studies and analysis of various performance measures to assess the contribution of tiltrotor technology to the Coast Guard missions.

3.3 Assumptions

The assumptions that are used for all three scenarios are described below. The assumptions associated with each specific scenario are contained in Section 5.0.

1. This study proceeds from the point of view that the mission requirements of the Coast Guard must be met affordably and that additional funding to achieve an enhanced capability will not be sought.

2. The study is set in 1998, which is the earliest time frame for which the operational impact of tiltrotor technology can be determined.

3. The study assumes that the V-22 is incompatible with operations aboard any current or planned Coast Guard ship. This incompatibility includes Helicopter In-Flight Refueling (HIFR).

4. Aerial refueling tankers are assumed to be unavailable to support Coast Guard operations for the purposes of this study.

5. The communications, navigation, and sensor suite performance for the V-22 is assumed to be equivalent to the capabilities of the suites onboard the current baseline aircraft.

6. Internal USCG reporting/communication procedures are assumed to be the same for all aircraft.

7. For this analysis, weather was assumed to affect all alternatives equally.

8. The study assumes FY 94 funding levels projected to FY 98.

9. This study assumes that Coast Guard endstrength, as well as manning of aviation units, will be held unchanged from the current manning levels.

10. Coast Guard basing, for the purposes of this study, will be unchanged from current basing.

11. Mission requirements, e.g., frequency of occurrence, are assumed to be no less than is currently demanded or than is forecast for FY 94 -98.

12. Those National interests, treaties, and policies currently in effect are assumed to continue unchanged for this study.

13. Current Coast Guard policies are assumed to remain in effect without change.

14. Current Coast Guard roles and relationships with other Federal, state, and local agencies are assumed to continue without change.

Section 4.0

System Descriptions

4.1 V-22 Osprey

A brief discussion of the history of the V-22 program is necessary to explain the selection of the V-22 configurations used for this study. The V-22 Osprey, as designed and developed by the joint efforts of Bell Helicopter Textron (BHT), Arlington, Texas and Boeing Helicopter Company (BHC), Philadelphia, Pennsylvania, stemmed from the requirements outlined in the JSOR, as last revised 13 February 1985. The program entered Full Scale Development (FSD) in February 1986 to define the production configuration of the V-22 aircraft. By October 1992, when the FSD contract was terminated, V-22 developmental flight testing was approximately 35% complete with 763 flight hours. In October 1992, the V-22 program was restructured and Engineering and Manufacturing Development (EMD) was begun to build and test four production representative aircraft to meet the Medium Lift Replacement (MLR) requirements. At the time of this study, an Operational Requirements Document (ORD) for MLR had not yet been approved and was not available for this study. Consequently, the V-22 configuration which would meet those requirements had not been completely defined. Therefore, although MLR may drive significant configuration changes which may impact aircraft performance, operational effectiveness, and operating and support costs, in lieu of a definition for the MLR requirement and configuration, this study is based on the V-22 configuration designed to meet the JSOR, i.e., the last approved requirement. This configuration, the most pertinent features of which are described below, is based primarily on the configuration designed for the Marine Corps assault support mission except as noted below. A complete system description of the V-22 may be found in the MV-22A NATOPS Flight Manual.

The V-22 Osprey is a tiltrotor VSTOL multimission aircraft designed to combine the vertical flight capabilities of a helicopter with the forward flight speed (463 km/hr maximum continuous level flight speed) and range (up to 3889 km unrefueled) capabilities of a fixed-wing turboprop airplane. The Osprey is a twin engine/twin rotor, high wing design with retractable, tricycle-type landing gear. The two 4586 kwatt Allison T406-AD-400 turboshaft engines are contained in the wing tip nacelles and drive 11.6 m diameter 3 bladed proprotors through the proprotor gearboxes which are interconnected to provide One Engine Inoperative (OEI) power to both proprotors. The tiltrotor design allows the nacelles to be rotated through a 97.5 deg arc, from horizontal in the fixed wing mode to slightly aft of vertical in the helicopter mode. The aircraft is designed to have a maximum vertical takeoff weight of 21,542 kg (24,943 kg maximum short

takeoff gross weight) and incorporates tandem cargo hooks designed to carry external loads up to 4,535 kg for single point or 6,803 kg for dual point operation. The design also incorporates a 272 kg capacity rescue hoist located at the cabin door. The V-22 is designed to be operated by a crew of four. The cabin is designed to carry up to 24 passengers or 9,070 kg of internal cargo. The passenger configuration can be converted to carry 12 litters. The aircraft is constructed primarily of composite materials and has been designed for improved reliability and maintainability over rotary-wing aircraft currently in the fleet. Cockpit lighting is designed to be compatible for Night Vision Goggle (NVG) operations. The V-22 incorporates a Flight Director system which is designed to be coupled with the Primary and Automatic Flight Control Systems to enable automatic, i.e., handsoff, control of the aircraft through programmed search patterns, as well as approach, hover, and departure profiles. The integrated avionics system considered for this study includes: dual AN/ARC-182 UHF/VHF radios, an AN/ARC-199 HF radio, and an AN/APX-100 transponder. Secure communication and IFF is provided by KY-58 and ANDVT encryption units and a KIT-1A/TSEC computer. The navigation suite includes an AN/APN-217 doppler radar, AN/ARN-118 TACAN, and AN/ARN-144(V) VOR/ILS/MB. Although currently not planned for the Marine Corps configuration, i.e., MV-22, for the purposes of this study, a radar capability was assumed with the incorporation of the AN/APQ-174 multifunction radar planned for the Air Force configuration, i.e., CV-22.

Two configurations of the V-22 will be examined in this analysis. The difference between the two versions lies in the amount of fuel each can carry. The first V-22 version, referred to as "V-22" in this document, is equipped with 13 fuel tanks, i.e., the USAF/USN fuel system configuration: an engine feed tank located in the outboard section of each wing, two sponson tanks located in the left and right forward sponsons, four auxiliary tanks in each wing, and a right aft sponson tank. This configuration is designed to carry 5,834 kg of usable JP-4 fuel. The second version, referred to as "V-22 with JSAFT", is equipped with 14 fuel tanks: the 13 tanks listed above, and a Joint Service Auxiliary Ferry Tank (JSAFT) located in the forward quarter of the cabin. This version carries 7,690 kg of usable JP-4 fuel.

4.2 HH-60J Jayhawk

The HH-60J is a single main rotor, twin-engine helicopter, manufactured by the United Technologies Corporation, Sikorsky Aircraft Division, Stratford, Connecticut. The aircraft is currently used by the Coast Guard to meet its Medium Range Recovery (MRR) mission, i.e., to locate, recover, and render assistance to persons in distress, as well as for logistics support, reconnaissance, and general utility. The HH-60 is scheduled to replace the HH-3F as the primary

resource for the LE apprehension mission in Operation Bahamas and Turks (OPBAT).The aircraft is designed to be operated by a crew of four and has seating for six passengers. The helicopter is equipped with two General Electric T700-GE-401C engines rated at 1239 kwatt maximum continuous power at sea level, standard day conditions. The four-bladed 16.5 m diameter main rotor and tail pylon may be folded for storage, enabling deployment aboard Bear and Hamilton class Coast Guard cutters. The helicopter is configured with a conventional fixed landing gear and an emergency flotation system. The aircraft has a maximum gross weight of 9,925 kg. The external cargo hook has a capacity of 2,721 kg and the rescue hoist, mounted externally above the right cabin door, is rated at 272 kg capacity. The aircraft configuration used in this analysis included two 455 liter and two 303 liter fuel tanks carried on pylon mounts. Cockpit lighting is compatible with NVG operations. The avionics system consists of dual AN/ARC-182(V) VHF/UHF-AM/FM radios and an AN/ARC-174A(V)2 HF radio. Secure communication is provided by KY-58 units. The transponder is an AN/APX-100 secured by a KIT-1A/TSEC computer. Navigation systems aboard the HH-60J include AN/APN-217 doppler radar, AN/ARN-118(V) TACAN, AN/ARN-147(V) VOR/ILS/MB, and AN/ARN-151(V) Global Positioning System (GPS). The avionics suite also incorporates a RDR-1300C weather/search radar and a FLIR 2000 Forward Looking Infrared (FLIR) system. A complete description of the HH-60J Jayhawk may be found in the HH-60J NATOPS Flight Manual.

4.3 HH-65A Dolphin

The HH-65A is a single main-rotor, twin engine helicopter manufactured by Aerospatiale Helicopter Corporation, Grand Prairie, Texas. The aircraft is currently employed by the Coast Guard to meet its Short Range Recovery (SRR) mission with secondary mission roles of patrol and observation, and external load operations. The HH-65A is the primary shipboard helicopter for cutter deployments in support of LE drug and fisheries operations and Polar Operations. The aircraft is designed to be operated by a crew of three and seats may be provided for at least five passengers. The helicopter is equipped with two Lycoming LTS-101-750B-2 engines rated at 507 kwatt for normal takeoff power at sea level standard day conditions. The rotor system consists of a single 11.9 m diameter, four-bladed main rotor which may be folded for shipboard parking or storage aboard Bear, Hamilton, and 210-class cutters. The aircraft is configured with a conventional, retractable, tricycle-type landing gear and an emergency flotation system The airframe is constructed primarily of composite, i.e., fiberglass, material. The maximum gross weight of the helicopter is 4,036 kg. The external cargo hook has a 907 kg capacity and the rescue hoist is rated at 272 kg capacity. The HH-65A Flight Director System is designed to enable automatic, i.e., hands-off, maneuvering of the aircraft along a mission computer programmed

route, to include search patterns, approach and transition to hover and departure ("go-around"). The avionics system incorporates dual AN/ARC-182 VHF/UHF-AM/FM radios, an RT-9600-17 VHF-FM radio and a 718U HF radio. Secure UHF, VHF, and VHF-FM communication is provided by the KY-58 (Vinson) secure voice system. The transponder is an AN/APX-100. Navigation systems aboard the HH-65A include AN/ARN-118 TACAN, dual AN/ARN-123 VOR/ILS/MB receivers, ADL-82 LORAN-C, OMEGA, Area Navigation (RNAV), and a RT-1301/C weather/search radar. Additionally, GPS installation is currently underway. A complete description of the HH-65A may be found in the HH-65A Flight Manual.

4.4 HC-130H Hercules

The HC-130H is an all-metal, high-wing, long-range, land-based monoplane manufactured by Lockheed-Georgia Company, Marietta, Georgia. The aircraft is designed to provide rapid transportation of personnel or cargo for delivery by parachute or by landing and is employed by the Coast Guard to meet the Long Range Search (LRS) mission. Additionally, the airplane is used in the missions of enforcement of laws and treaties including illegal drug interdiction, fishery enforcement, military readiness, marine environmental protection, and international ice patrol. The HC-130H is designed for landing and takeoff on short runways. Four 3661 kwatt Detroit-Diesel Allison T56 turboprop engines are mounted on the wings and drive Hamilton Standard four-bladed, 4.1 m diameter propellers. The aircraft is designed for a maximum gross weight (peacetime) of 70,295 kg and can carry up to 86 passengers. When used as an ambulance, the aircraft can carry 66 litters. The Coast Guard normally operates the aircraft with a crew of seven. The HC-130H autopilot system when coupled to the Flight Director System is designed to enable automatic, i.e., handsoff maneuvering of the aircraft along a commanded route, to include search patterns. Although the avionics configuration of the HC-130H is not standard across the Coast Guard fleet, the communications suite of the most recent HC-130H series includes dual AN/ARC-182(V) VHF/UHF, AM/FM radios secured by KY-58 encryption units and dual AN/ARC-94 HF radios secured by KY-75 encryption units. The dual transponders are AN/APX-100 systems. Similarly, the navigation systems aboard the most recent HC-130H series include dual AN/ARN-118 TACAN receivers, dual AN/ARN-123 VOR/ILS/MB receivers, LTN-72 Inertial Navigation System, LTN-211 OMEGA, and ADL-81 LORAN C receiver. The avionics suite also incorporates an AN/APN-215(V) weather radar and the AN/APS-137 sea search radar. GPS installation is scheduled for all HC-130H aircraft. A complete description of the HC-130H may be found in the USCG Series, HC-130 Flight Manual and performance data may be found in USAF Series, H-130 Flight Manual for Airplanes Equipped with T56-A-15 Engines.

4.5 HU-25A/B/C Guardian

The HU-25 aircraft is an all-metal monoplane manufactured by Dassault-Brequet Aviation and assembled by Falcon Jet Corporation, Little Rock, Arkansas. Two Garrett ATF3-6 turbofan engines capable of producing 24,200 newton thrust at sea level standard day conditions are mounted on pylons on the aft fuselage. The maximum takeoff gross weight of all HU-25 aircraft is 14,512 kg and the aircraft seats nine passengers. The HU-25 autopilot system when coupled to the Flight Director System is designed to enable automatic, i.e., handsoff, maneuvering of the aircraft along a commanded flight path and may include search patterns. The three HU-25 series configurations differ primarily in mission equipment.

The HU-25A is employed in the Coast Guard Medium Range Search (MRS) mission and is equipped to perform search and rescue, enforcement of laws and treaties, and maritime environmental protection missions. The normal crew for the HU-25A is a pilot, copilot, dropmaster, avionicsman, and one aircrewman. The communication suite includes dual 618M-3 VHF-AM radios, an AN/ARC-159(V) UHF radio, dual 671U-4A HF radio, and an AN/ARC-160 FM radio. Secure communications are provided for UHF radio by the KY-58 (Vinson) system and for the dual HF radios by the KY-75 (Parkhill) system. The dual transponders are AN/APX-72 systems. The navigation system includes dual VIR-31A VOR/ILS receivers, AN/ARN-118(V), Area Navigation (RNAV), LTN-72 Inertial Navigation System, and ADL-81 LORAN. An AN/APS-127 weather/search radar and "Stormscope" is also provided.

Seven HU-25 aircraft have been configured as HU-25B AIREYE for the Medium Range Detection (MRD) mission and are equipped primarily for use as an ocean surveillance system to support various Coast Guard missions. The aircraft has the same avionics as the HU-25A but also features the AN/APS-131 Side-Looking Airborne Radar (SLAR), the RS-18C infrared/ultraviolet line scanner, and the KS-87B aerial camera. The normal crew for the HU-25B is a pilot, copilot, sensor system operator, and one aircrewman.

Nine HU-25 have been configured as the HU-25C Nightstalker for the Medium Range Intercept (MRI) mission specifically for the airborne detection and interception of drug smuggling aircraft. The avionics suite differs from the HU-25A/B in that the RT-9600 VHF-FM radio and LTN-72-29-02 Inertial Navigation System replace comparable systems in the HU-25A/B. The most significant change to the avionics system is the replacement of the AN/APS-127 with the

AN/APG-66 air intercept radar and addition of the WF-360 FLIR system. The normal crew is a pilot, copilot, sensor system operator, and additional crew members as required for the mission.

A complete description of the HU-25A/B/C may be found in the HU-25 Flight Manual.

Section 5.0

Operational Effectiveness Analysis

The operational effectiveness analysis results are presented in three sections; each section corresponds to one of the USCG scenarios. For a complete listing of the results generated by each scenario analysis, refer to Appendix B.

5.1 Search and Rescue (SAR)

The principal objective of the Search and Rescue (SAR) program as stated in the USCG SAR Program Standards memorandum is to minimize loss of life, personnel injury, and property loss and damage.

5.1.1 Scenario Definition

The Coast Guard will use every available asset to perform a SAR mission including local civilian, military, and foreign assets. USCG aircraft performing other missions may be diverted to participate in a SAR effort. This analysis is concerned only with Coast Guard aircraft, i.e., HH-65A, HH-60J, HC-130H, and HU-25A,B,C, deployed from a Coast Guard Air Station (CGAS) for comparisons with the V-22.

Figure 5-1 depicts a typical SAR scenario. For the purposes of this study, the SAR mission is divided into three functional areas: initial response time, enroute time, and time on station.

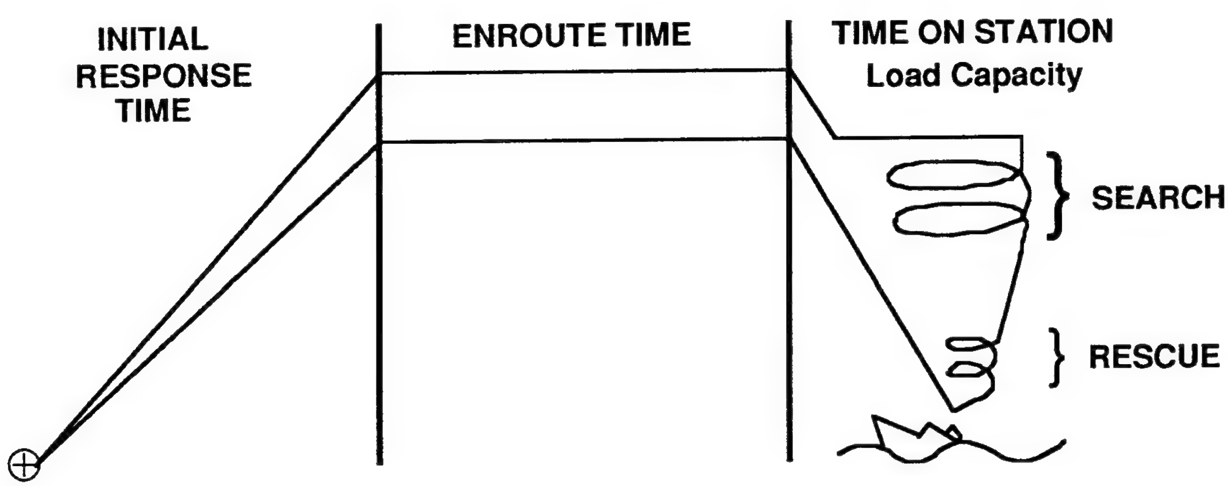


Figure 5-1 - SAR Scenario

The initial response time is defined as the time required to man an aircraft, perform all preflight checks, warm-up essential navigation and communications equipment, and launch. This scenario begins when an overdue vessel is reported to local authorities. The local authorities forward the report to the Coast Guard Rescue Coordination Center (RCC) which, in turn, notifies the appropriate Coast Guard Air Station. Since the internal Coast Guard communications network functions the same for all aircraft, it will not be discussed further.

Timely response is a key element in the prevention of loss of life and property and accomplishment of a successful SAR mission. A comprehensive study of the SAR program, conducted from 1967 through 1971, established the expected survival time of a person in the water (without an anti-exposure suit) based on water temperature. Figure 5-2 illustrates the correlation between water temperature and survival time assuming an average water temperature of 18 deg C. These findings led to the Coast Guard establishment of a two hour total response standard which was revalidated by the Coast Guard Search and Rescue Division in CY 1992. Examination of Figure 5-2 indicates that survival probability is reduced to less than 50% after four hours in the water at the median temperature assumed for this analysis. The total response time is defined as the time required to arrive on scene at datum or the search area. For the purpose of this study, that time is the sum of initial response time and enroute time.

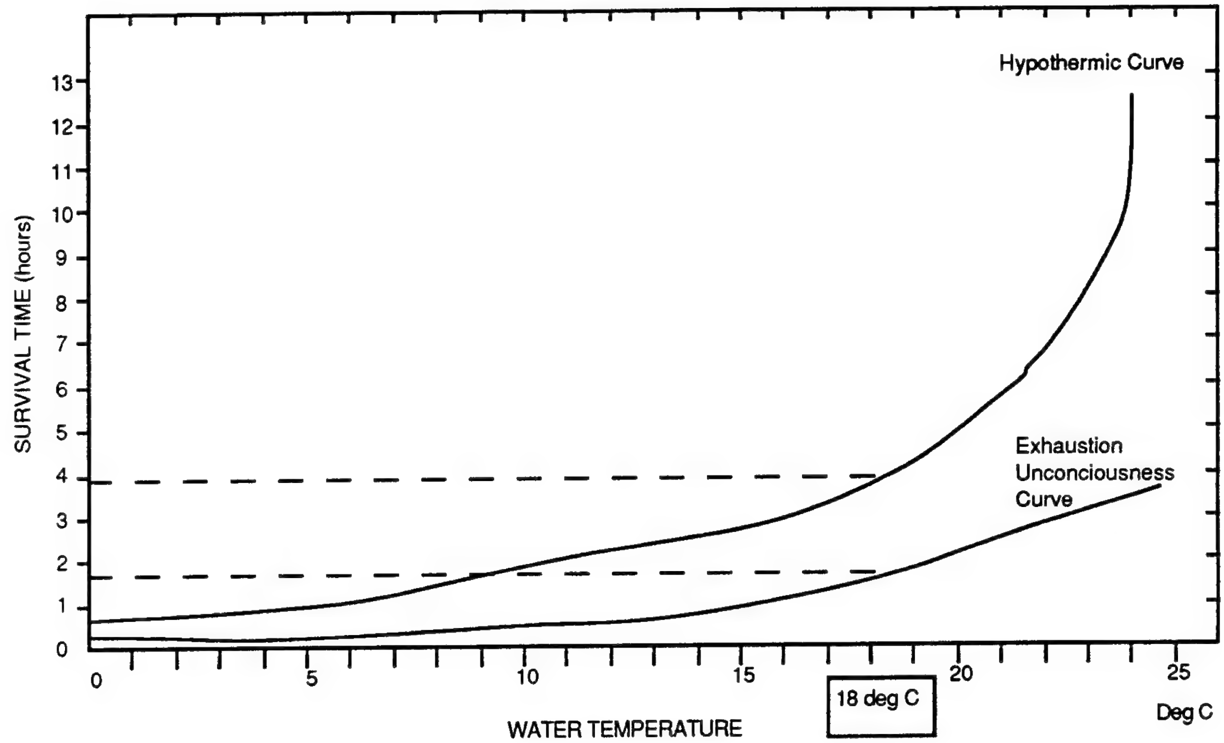


Figure 5-2 - Survival Chart

Coast Guard memorandum, "SAR Program Standards," dated 11 January 1993, validated the definition of B-0 alert status which required that the SRU must be ready to launch within 30 minutes after receiving the distress report. During this initial response time, alert-crews man the aircraft and initiate warm-up of onboard navigation and communications equipment and plan the flight based on information received from the RCC.

The enroute time of the scenario begins when the aircraft is launched. The SAR Program Standard for transit indicates that the SRU must arrive on scene, at datum, or in the search area within 90 minutes of launch. Enroute time, combined with the initial response time, must also satisfy the two hour total response time standard. Although the actual aircraft transit speed used may consider the distance and certainty of position of the incident, this analysis uses a single enroute airspeed and fuel flow regardless of distance.

Time on station begins upon reaching the search area where the Search and Rescue Unit (SRU) enters the search phase of the scenario by initiating any of several standard search patterns in accordance with the National SAR Manual. Although typically more than one aircraft is

involved in the search, this study compares a single V-22 with the one or more baseline aircraft required to perform all aspects of the mission. The study assumes a search conducted under conditions of daylight hours, a search altitude of 460 m, visibility of 28 km, and a coverage factor of 1.0. Weather and crew fatigue were not factors. Under these conditions, according to the National SAR Manual, the probability of detection on a single pass search is 78 percent. For this study, the primary sensor used by all aircraft for searching for small boats and victims in the water is the human eye. The search speeds used for this study are 334 km/hr for fixed-wing aircraft and 167 km/hr for rotary wing aircraft. The SRU continues the search until the distress site is located or until refueling is necessary.

The rescue phase begins when the victims are located. During this phase, the SRU assists victims by providing necessary equipment such as pumps or rafts, inserting a Rescue Swimmer (RS) who may provide immediate emergency medical care and/or assist in hoisting personnel from the craft, a life raft, or from the water.

After all victims are picked up or the aircraft is full, the SRU will transport the victims to the nearest medical facility. For simplicity, the medical facility is assumed to be collocated with the Air Station or at the same distance as the Air Station. Refueling is not considered and the scenario ends when all victims are rescued or available fuel is expended.

5.1.2 SAR Measures of Effectiveness/Measures of Performance

The Coast Guard memorandum, "SAR Program Standards," dated 11 January 1993, describes two measures of effectiveness the Coast Guard uses as general indication to evaluate the success of the SAR program are:

$$\text{Percentage of Lives Saved} = \frac{\text{Lives Saved}}{\text{Lives Saved + Lives Lost}}$$

$$\text{Percentage of Property Saved} = \frac{\text{Property Saved}}{\text{Property Saved + Property Lost}}$$

The Coast Guard goals are to save, after Coast Guard notification, at least 90% of the personnel alive at the time of notification and prevent the loss of 70% of the property at risk of destruction. Based on historical data, the Coast Guard consistently has met or nearly met these goals with past and current aircraft assets. Adequately and accurately assessing the impact the

V-22 might have on these percentages or predicting the impact on future data would be difficult, therefore, these measures are not used in this study. However, based on the breakdown of the SAR mission into its functional elements, a number of other measures are available to enable an adequate effectiveness comparison among the available alternatives.

The SAR functional areas are illustrated in Figure 5-3 as a flow chart indicating the items influencing each functional area. These items will become the analysis measures. Measures of effectiveness (MOEs) and measures of performance (MOPs) for all baseline aircraft will be compared with the V-22 and V-22 with JSAFT (an internal fuel tank).

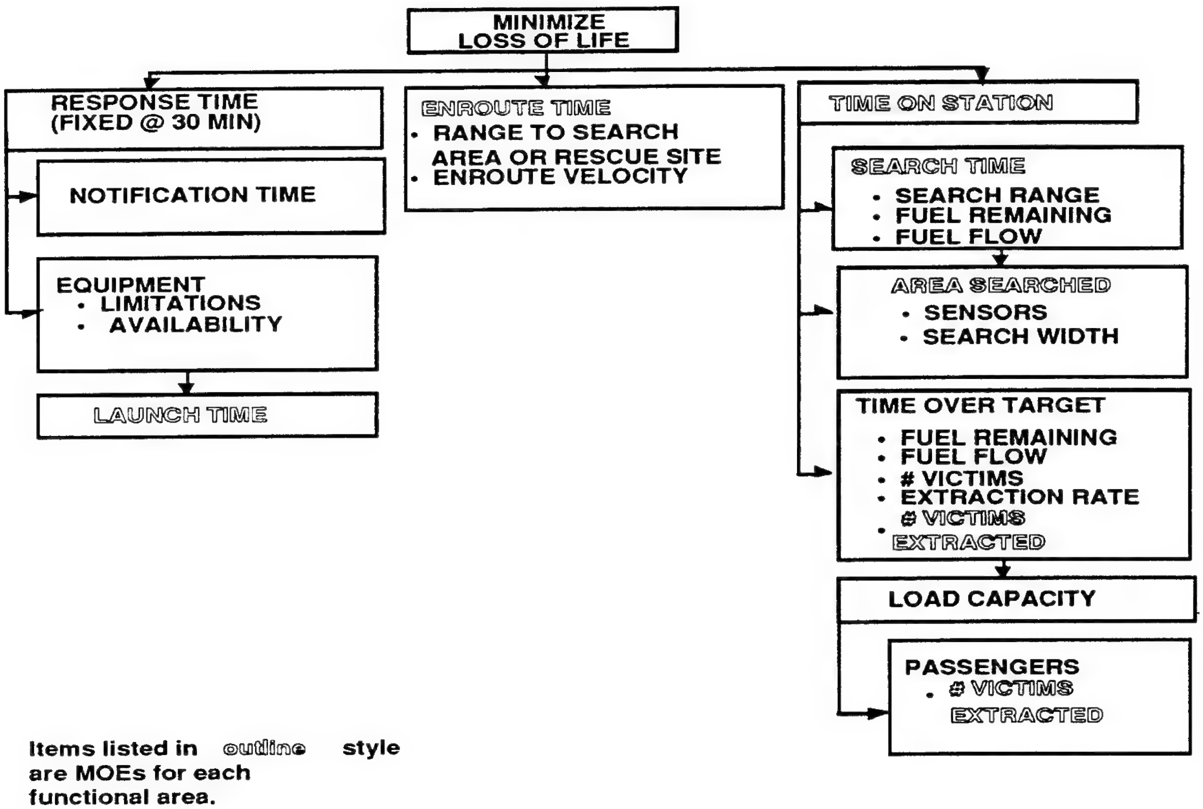


Figure 5-3 - SAR Functional Area Flow Chart

The measures used in this analysis are identified in Table 5-1. These measures depend on performance characteristics of the various aircraft such as airspeed, fuel flow, and passenger capacity. Although characteristics are dynamic and vary with environmental factors such as temperature, air density, and altitude, this analysis uses a more simplified approach of assigning single representative values to the variables.

Table 5-1 - SAR Functional Area MOE/ MOP

Functional Area	Analysis Measures
Response Times	• Launch time
Enroute time	• Enroute Time
Time on station	• Time on Station • Search time • Area searched • Number of victims extracted

The analysis assumes that aircraft placed on B-0 alert status are fueled, loaded with appropriate SAR equipment, and preflighted. The aircraft is equipped with a standard SAR equipment loadout tailored for each aircraft type. The time required for an aircraft to launch is a function of aircraft maintainability, reliability and the warmup time required for the navigation and communication equipment onboard. Discussions with operational USCG pilots indicate that SAR crews consistently meet the 30-minute launch requirement. Consequently, for the purposes of this analysis, a 30-minute launch time will be assumed for all aircraft.

Enroute time is directly related to the distance to the search area, the transiting airspeed, and associated fuel flow. The enroute time plus the initial response time must total two hours or less to meet Coast Guard requirements.

Time on station (TOS) is the sum of the search time and the time over the target (or rescue time). If the location of the victims is known, the search distance and time is zero and the TOS is the time spent in the rescue phase. The time over target is based on the number of victims requiring extraction and is calculated at 5 minutes per victim. For cases where hoist extraction cannot be conducted, the rescue time (and time over target) is zero and TOS is the search time.

Search time depends on the aircraft speed and the distance traveled during the search. This study assumes that a search for personnel or a raft in the water or for a small craft will be conducted visually. Fixed wing aircraft and the V-22 were assumed to use an airspeed of 334 km/hr in the search. The rotary wing aircraft were assumed to use 167 km/hr. The distance an aircraft can search is restricted by its usable fuel minus reserve fuel.

The effective visual sweep width is a function of target size, visibility, surface conditions and aircraft speed and altitude. The visual sweep widths used for this analysis were taken from the

National SAR Manual for a four-man liferaft, 28 km visibility, and seas of less than 0.6 m. The aircraft search altitude was 460 m for all aircraft. The fixed-wing aircraft were assumed to be flying at 334 km/hr while 167 km/hr was used for the rotary-wing aircraft. The V-22 was evaluated at both fixed-wing and rotary-wing airspeeds. The analysis assumed a search coverage factor of 1.0, i.e., no overlaps for a single search. The visual sweep widths for the above conditions are 3.9 km for fixed-wing aircraft and 5.0 km for rotary wing aircraft.

The rescue time is a function of the number of victims and available fuel. The rescue time is related to the amount of fuel remaining and hover fuel flow. The quantity of fuel available to conduct a rescue depends on the amount of fuel used during the search and the enroute distance to the search area. The maximum number of passengers each aircraft can carry is a physical limitation of the various aircraft. While time to extract victims from a rescue site can vary dramatically depending on conditions such as weather and victims' condition, discussions with operational USCG pilots suggest that an average time of five minutes per victim is reasonable.

5.1.3 SAR Analysis Methodology

The measures listed in Table 5-1 were used to compare the operational effectiveness of the tiltrotor technology, as represented by the V-22 and the V-22 with JSAFT, with the current baseline USCG aircraft in the SAR scenario. Performance data used in the analysis were extracted from aircraft flight manuals, USCG policies and procedures, and the SAR Manual as depicted in Table 5-2.

Table 5-2 - Aircraft Performance Characteristics

Characteristics	Units	HU-25	HH-60	HH-65	HC-130	V-22	V-22 W/JSAFT
Total Useable Fuel (FT)	kg	4536	2930	854	28531	5835	7583
Start/Warm-up Fuel (FST)	kg	221	64	45	454	45	45
Landing Fuel (FLand)	kg	874	172	79	1916	398	409
Velocity Enroute (VE)	km /hr	667	233	233	463	463	463
Fuel Flow Enroute (FFE)	kg/hr	1166	515	237	2554	1193	1225
Velocity Search (VS)	km/hr	334	167	167	334	334 [1]	334 [1]
Velocity Search (VS)						167 [2]	167 [2]
Fuel Flow Search (FFS)	kg/hr	510	413	191	1752	1007 [1]	1066 [1]
Fuel Flow Search (FFS)	kg/hr					1512 [2]	1600 [2]
Fuel Flow Rescue (FFR)	kg/hr	N/A	646	272	N/A	1932	1932
Max Passenger	#	N/A	6	4[3]	N/A	24	18
Sweep Width (W)	km	3.9	5.0	5.0	3.9	3.9 [1]	3.9 [1]
Sweep Width (W)	km					5.0 [2]	5.0 [2]

[1] Fixed-wing search mode
[2] Rotary-wing search mode
[3] With rescue swimmer

5.1.3.1 Assumptions

This analysis is based on the following assumptions:

1. The V-22 rotor wash is within acceptable limits for a SAR mission.

2. The incident location is unspecified.

3. The initial response time for all aircraft is 30 minutes.

4. The water temperature is 18° C and the air temperature is 15° C.

5. Communications and navigation capabilities are assumed to be equivalent for all aircraft. Avionics and sensor suites are assumed to be equivalent for all aircraft and do not differentiate the search capabilities of the aircraft. A visual search is assumed for all aircraft.

6. Crew composition was assumed to be not a factor in visually detecting the target.

7. The aircraft did not refuel.

8. Extraction time per victim is five minutes regardless of the aircraft type.

9. The return distance is the same as the enroute distance.

10. Sweep width is 3.9 km for fixed-wing aircraft and 5.0 km for rotary wing aircraft at a search altitude of 460 m; search airspeeds of 334 km/hr and 167 km/hr for fixed and rotary wing aircraft, respectively; visibility of 28 km; good weather; coverage factor of 1.0.

5.1.3.2 Measures of Effectiveness/Measures of Performance

Distances to the search area or rescue site were varied in range from 37 km to over 2500 km and the performance, or effectiveness, of each aircraft type was evaluated. Although the vast majority of SAR incidents occur within 37 km from shore, a Coast Guard SRU is not always within 37 km of the victims. The SARMIS database was used to determine the distribution of incidents/victims relative to the location of the Coast Guard unit.

As stated previously, the initial response time is assumed to be 30 minutes for all aircraft types.

The enroute time is the time required to travel to the search area or rescue site and is determined by dividing the distance to the search area by the enroute velocity. The enroute airspeed was assumed to be at best cruise airspeed. The total response time, which must be two hours or less to meet USCG standards, is the sum of the initial response time and the enroute time. The return time from the rescue site to an aid station is assumed to be equal to the enroute time.

The time on station (TOS) is the sum of the search time and the time over target (or rescue time). If the location of the victims is known, the search time is zero and conversely, if the victims are not located, the TOS is the time spent searching. Search time is a function of the distance traveled during the search divided by the search velocity of the aircraft.

The rescue time may be calculated in two ways. One depends on the number of victims to be extracted and the other depends on the amount of fuel available and the fuel consumption in a

hover during the extraction. The rescue time required to extract the victims is calculated by multiplying the number of victims by the rate of extraction per victim which is assumed to be five minutes. However, the rescue time may also depend on the amount of fuel available at the conclusion of the search. To calculate this fuel quantity, other fuel quantities such as the fuel used from takeoff to the conclusion of the search and the bingo fuel must first be calculated. Bingo fuel is the fuel needed to return and safely land at the Air Station with the required fuel reserve. The enroute fuel is calculated by multiplying the enroute time by the enroute fuel flow. The search fuel is similarly calculated by multiplying the search by the search fuel flow. Bingo fuel is the sum of the reserve fuel and enroute, i.e., return, fuel. The rescue fuel is the total fuel minus the sum of the start-up fuel, enroute fuel, search fuel, and bingo fuel. Rescue time is calculated by dividing rescue fuel by the fuel flow used while hovering. The rescue time is the smaller of the two calculations.

The maximum TOS, which is also the maximum search time, is calculated by dividing the maximum available fuel by the search fuel flow. The maximum fuel available is determined by subtracting the sum of the startup fuel, the enroute fuel and the bingo fuel from the total fuel. The maximum search distance the aircraft can fly before having to return to base may be obtained by multiplying the maximum search time by the search velocity. The maximum search area is the product of the maximum search distance and the sweep width.

5.1.4 SAR Analysis Results

The analysis results for the SAR scenario are presented in Sections 5.1.4.1 through 5.4.1.3 for the three functional areas: response time, enroute time, and time on station. The formulas used in this analysis are contained in Appendix B.

5.1.4.1 Response Time

The initial response time for all aircraft used is 30 minutes. Since this measure of effectiveness is constant for all aircraft, it will not be considered further.

5.1.4.2 Enroute Time

The SAR standard is to arrive in the search area or at the rescue site within two hours of notification. Assuming an initial response time of 30 minutes, the search area or rescue site must be arrived at within 90 minutes of launch. As shown in Figure 5-4, all aircraft were capable of reaching the search area within the 90 minutes for distances of 483 km or less. The HU-25, C-130, and V-22 could meet the time standard at distances of up to 927 km .

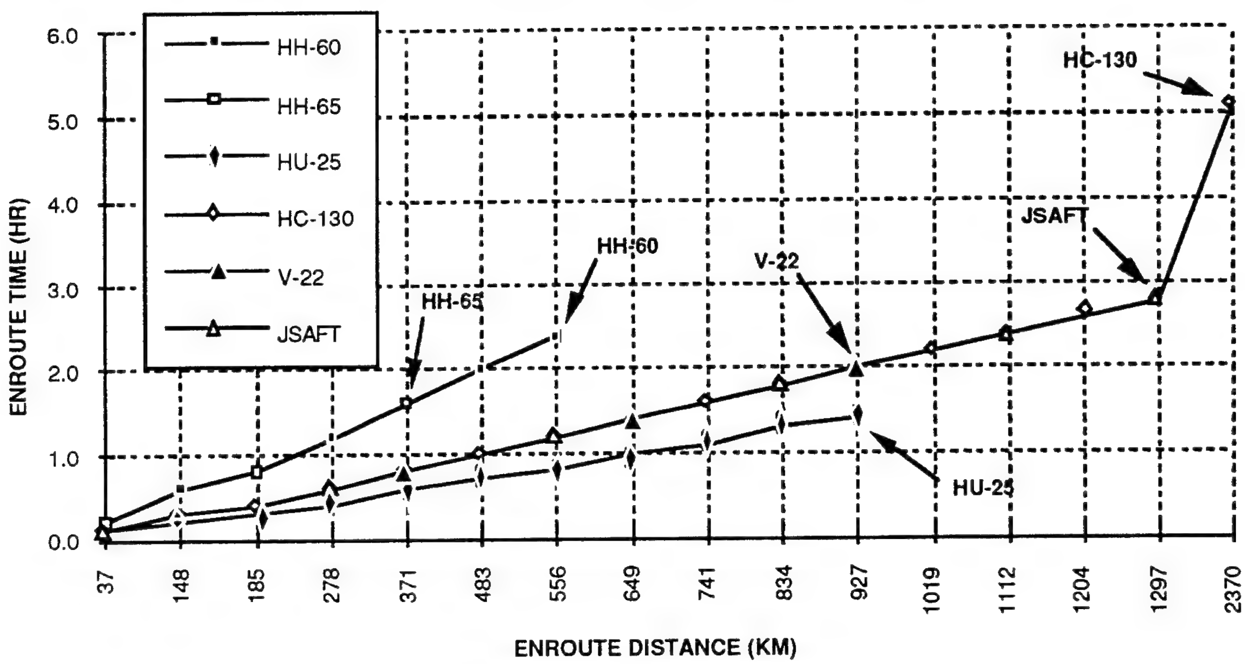


Figure 5-4 - Enroute Time vs Enroute Distance

5.1.4.3 Time On Station (TOS)

As a measure of effectiveness, TOS did not differentiate the alternatives, i.e., it showed no advantages or disadvantages among aircraft. However, its component parts, i.e., search time, area searched, time over target, number of victims saved, and the percentage of incident database covered were valid measures.

5.1.4.3.1 Search Time

The time to locate victims can be reduced to a function of distance and airspeed for the enroute and search phases. The speed advantage of the fixed wing aircraft over the rotary wing

aircraft is decreased during the search phase due to the reduced speeds required when using the human eye as the searching sensor. However, in the case depicted in Figure 5-5, the time for the fixed wing aircraft to travel the search distance was still approximately one half that for the HH-60 and HH-65. The HH-65 was incapable of performing missions beyond 371 km due to lack of fuel. The performance of the HU-25, HC-130H, and the V-22 were nearly equal. In the helicopter configuration, the V-22 alternatives were unable to complete search missions beyond 741 km. The HU-25, HC-130H, and V-22 were capable of finding the victims within the four hours window in all cases depicted. The HH-60J was capable of finding the victims within four hours except in the 741 km case, in which case, it took nearly 6 hours to travel the search distance.

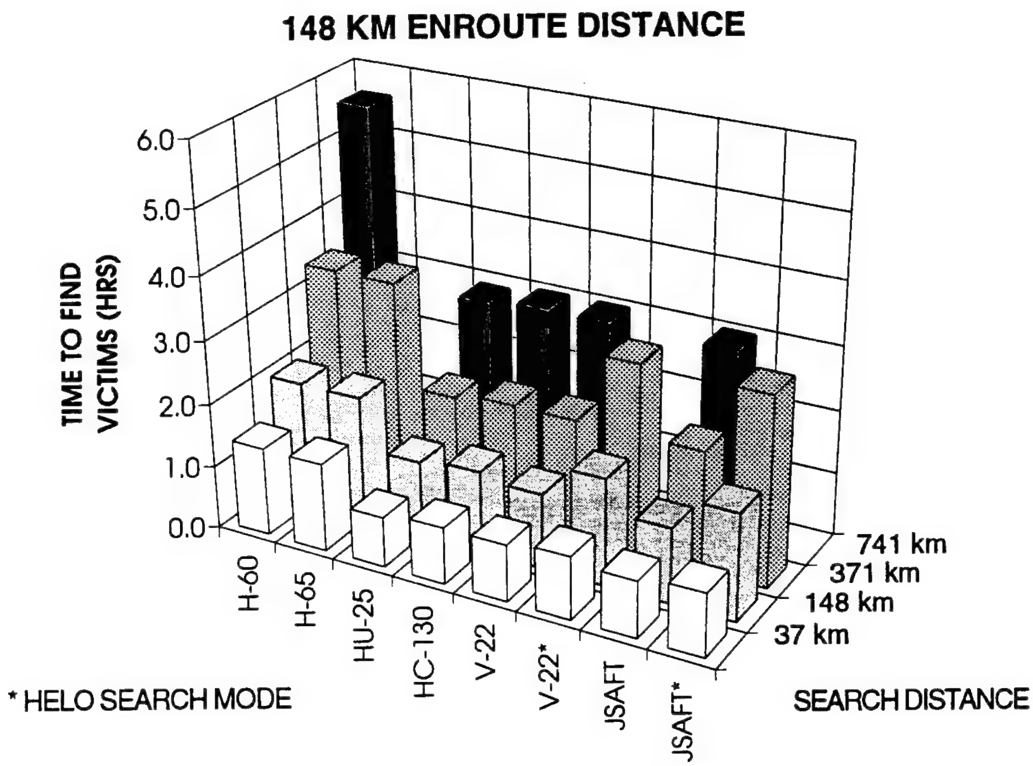


Figure 5-5 - Time Required to Find Victims

5.1.4.2.2 Area Searched

The maximum search area capability of each aircraft is primarily a function of its fuel capacity and fuel flow. The values depicted in Figure 5-6 represent the maximum search area, i.e., the area covered at search airspeeds for searches starting at the air station with no enroute time considered. If the aircraft started the search at some point away from the air station, the total area

each could cover would decrease. As shown in the figure, the HC-130H relative search capability of 19450 km^2 greatly exceeds all the other aircraft. The HU-25 is second at 8789 km^2. The V-22 with JSAFT is very nearly the same as the HU-25 when used in the fixed-wing configuration. The search capability of the V-22 in the fixed-wing mode is more than twice that in the rotary wing aircraft.

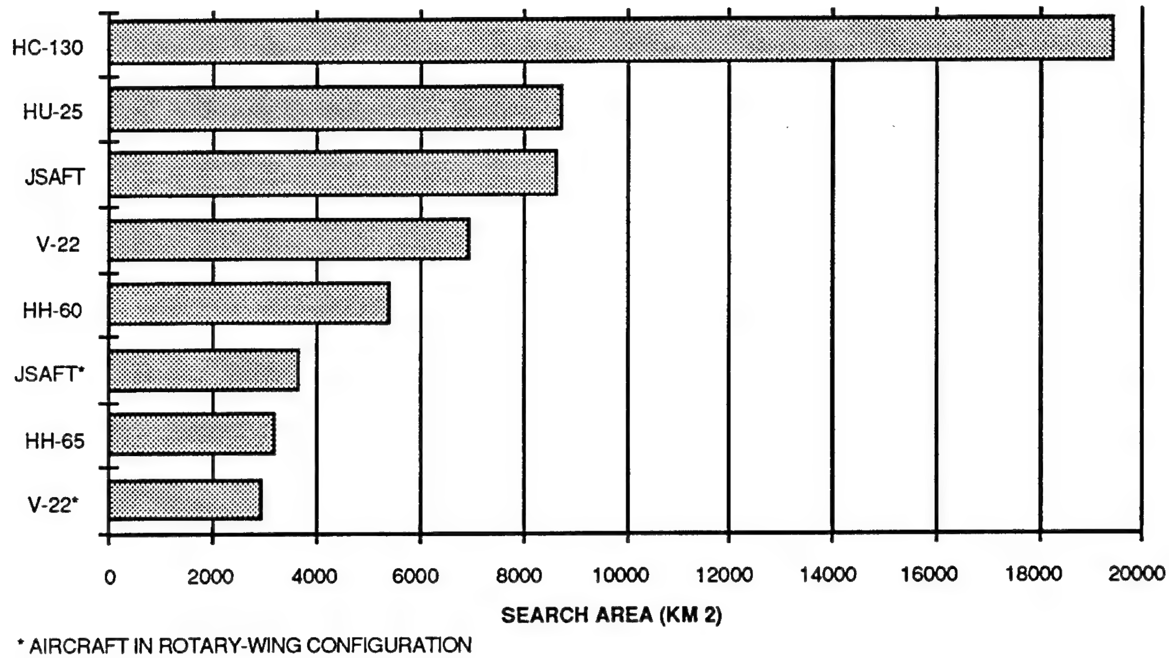


Figure 5-6 - Maximum Search Area Capability

5.1.4.2.3 Victims Extracted

Analysis of the SARMIS data base for the period 1988 through 1992 indicates that 90% of the SAR cases involving hoist extractions were for extractions of four or fewer personnel. Cases of six or fewer hoist extractions accounted for approximately 94% of the SAR cases. Over 99% of the SAR cases involved twenty-four or fewer hoist recoveries. Therefore, considering only passenger capacity , a single HH-65A could have handled 90% of the incidents involving hoist recoveries; a HH-60J, 94%; and a V-22, over 99% of the SAR hoist recoveries.

Assuming a hoist extraction requirement of four personnel, i.e., 90% of the SAR cases, and a positive fix on the rescue site such that no search time is required, the HH-65A has an operational radius of action of approximately 312 km. The operational radius of the HH-60J to transit to the site, hoist four survivors, and return the same distance is approximately 557 km.

Four survivors can be hoisted from a rescue site about 921 km from the CGAS with the V-22 and about 1225 km with the V-22 equipped with JSAFT.

Developmental flight tests by the Naval Air Test Center of the V-22 in low hovers overland indicate that "the V-22 has a significantly greater flow field depth, velocity magnitudes, and force magnitudes than all Navy and Marine operational helicopters." However, another set of V-22 flight tests designed to evaluate the feasibility of external cargo operations suggests that an area of relatively low downwash exists directly below the aircraft which enabled the execution of external load connections. To date, flight tests have been limited in scope and have not evaluated either rotor wash in over-water hovers or modified operational techniques for hoist rescues. Further testing of the V-22 appears warranted in this area.

Figure 5-7 represents historical data for the years 1988-1992 obtained from the SARMIS data base. Of all the incidents involving aircraft, 76% of the incidents occurred within 185 km from the aircraft launch site. In this case, the HH-65A is the primary SAR aircraft. Approximately 95% of all cases happened inside 555 km and were covered by the current cadre of aircraft. The medium range recovery capability is represented in Figure 5-7 by the HH-60J; however, prior to 1992, the HH-3F filled the MRR mission for the Coast Guard. Both HH-3F and the HH-60J statistics are included in Figure 5-7. The medium range search aircraft is primarily the HU-25. Beyond 555 km, long range search is accomplished by the HC-130H. The range of the V-22 configurations under evaluation would have provided not only a long range search capability to locate and drop equipment to rescue sites beyond 555 km but also a long range recovery capability to execute extractions if necessary.

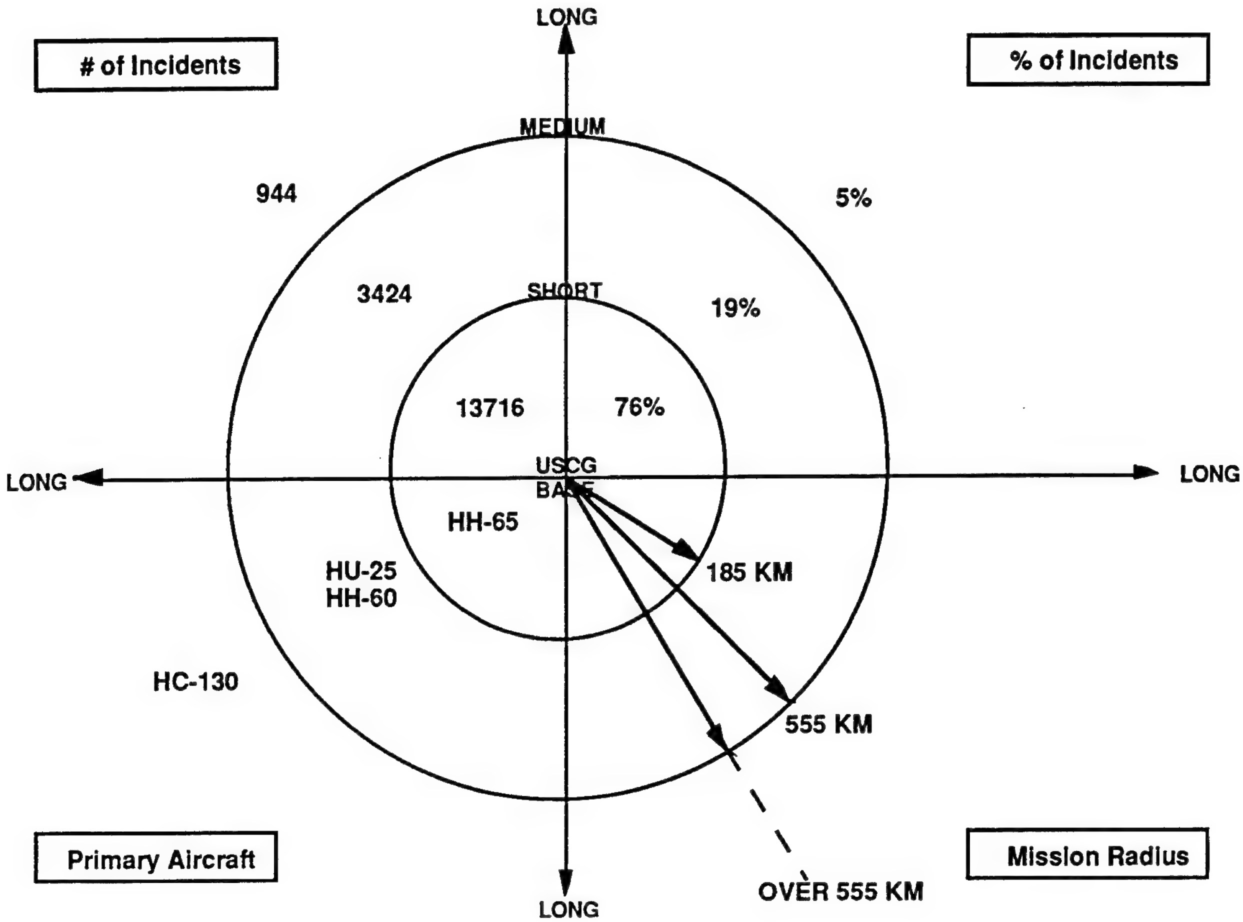


Figure 5-7 - Five Year Historical Representation of SAR Missions

5.1.4.3 SAR Analysis Results Summary

All fixed wing aircraft met the required 2.0 hour response plus enroute time for enroute ranges of 717 km or less and responded in approximately half the time of the rotary wing aircraft. The HH-65A fuel limitations significantly restricted the distance covered within the response time standard.

The performance of the V-22 in the fixed wing mode closely approximated the HU-25 and the HC-130H during the search phase of the SAR mission. The V-22, as well as the HC-130H and the HU-25, were able to locate the victims in about half the time of the rotary wing aircraft. The rapid location of the victims would contribute directly to the number of lives that might be saved through reduction of drowning caused by exhaustion and hypothermia. The increased passenger capacity of both V-22 alternatives would enable a single aircraft to be used to recover

victims in the average 6.85 cases per year which involve hoist extractions of between 7 and 24 victims.

The HC-130H area search capability far exceeded all other alternatives. The V-22 with JSAFT provided essentially the same search capability as the HU-25 and both V-22 configurations enabled the extraction of victims at long ranges without requiring additional aircraft specifically to effect the extraction. All aircraft have the capability to provide equipment through airdrops.

The large majority of SAR cases, i.e., 95%, occur within the range of all aircraft and involve small numbers of victims. The V-22 capabilities not only match existing USCG SAR capabilities but also address those cases involving large numbers of survivors and/or long distances which currently are not met by the USCG aircraft fleet. Within the scope of this study, the application of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of search and rescue at sea offers an increase in effectiveness over the current baseline systems. This conclusion is contingent on whether future flight testing demonstrates a viable operational capability of hoist extraction of personnel from open water.

5.2 Law Enforcement (LE)

The Law Enforcement (LE) program has two main objectives. The first program objective is to enforce or assist in the enforcement of all applicable Federal laws over, on, and under the high seas and waters subject to the jurisdiction of the United States by all appropriate means, except those laws related to pollution, traffic control, or port and vessel safety. The second LE program objective is to preserve and protect the living and non-living natural resources of the United States.

The LE program has varied requirements across its mission areas due to the diverse nature of the individual activities. The mission areas that the LE program is responsible for include the following:

- UN Driftnet moratorium - The primary objective for this mission is to monitor compliance with the UN Moratorium on large scale high seas pelagic driftnet fishing.

- Enforce Closed Fishing Area - The primary objective of this mission is to enforce closure of certain fishing areas. Vessels may not fish some areas and the use of certain equipment, or certain types of fishing, may also be prohibited in these areas.

The areas are scattered throughout the Coast Guard area of responsibility ranging from western Pacific to the Atlantic Ocean.

- Prevent Poaching by Foreign Fishing Fleets within the Exclusive Economic Zone (EEZ) - The primary objective for this mission is to prevent incursion by foreign fishing fleets within the EEZ, territorial sea and internal waters.

- Maritime Interdiction of Illicit Drugs - The objectives for this mission are to interdict and deter drug traffickers who are attempting to smuggle illegal drugs into the United States via maritime routes.

- Airborne Interdiction of Illicit Drugs - The objectives for this mission are to interdict and deter drug traffickers who are attempting to smuggle illegal drugs into the United States using aircraft.

- Interdiction of Illegal Aliens - The primary objective for this mission is to detect and interdict aliens attempting to enter the United States via the high seas.

This analysis concentrates only on the maritime drug interdiction mission area. USCG drug interdiction is a high profile mission. The responsibility of airborne interdiction is not unique to the USCG; they share the responsibilities with the U.S. Customs Service. The maritime interdiction mission on the high seas, however, is solely the responsibility of the USCG. Therefore, this section will be devoted to the development of the LE maritime interdiction (LE/MI) scenario.

5.2.1 LE/MI Scenario Definition

A large portion of the LE/MI mission involves patrolling the high sea in an effort to interdict/deter traffickers. The map shown in Figure 5-8 illustrates the routes used for typical smuggling missions.

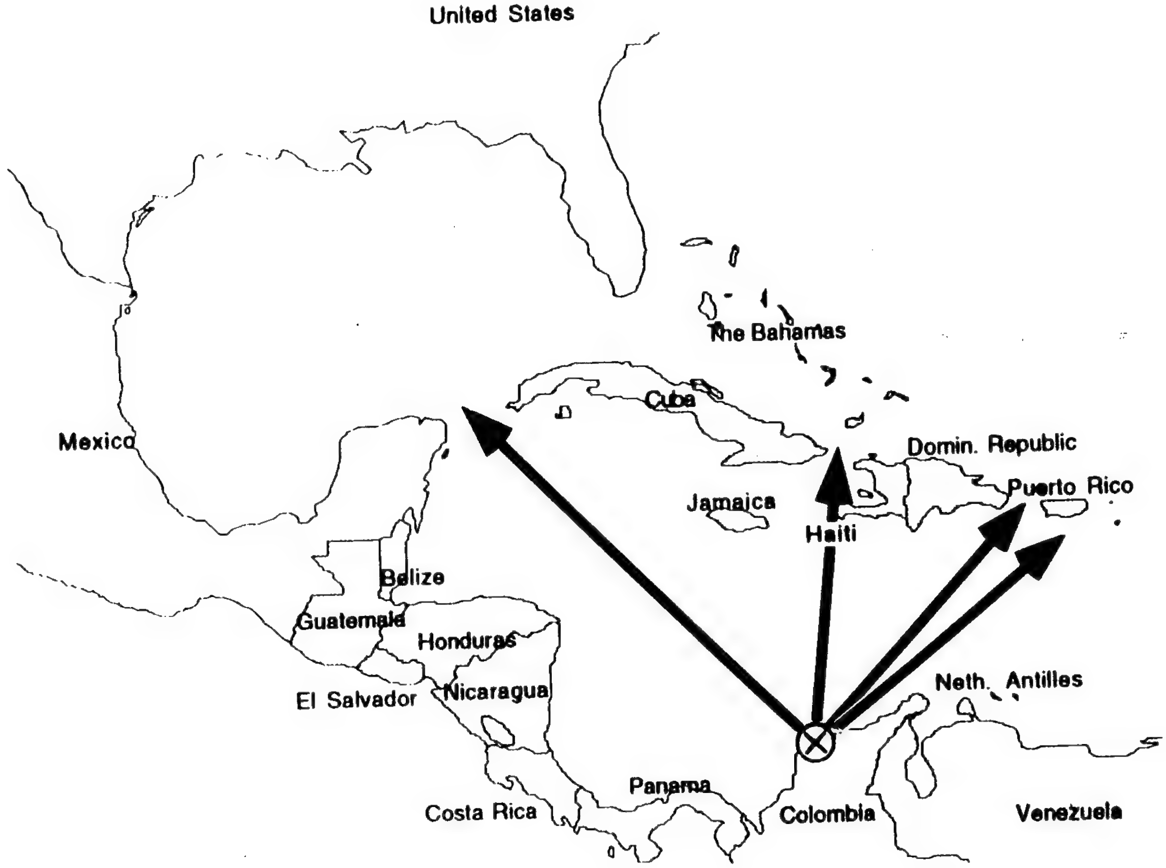


Figure 5-8 - LE/MI Scenario

The scenario begins in Columbia where a private boat (typical sizes range from 8 m to 70 m in length) is loaded with illegal drugs. The boat has four possible routes it could take to the U.S. If the boat was making the drop in the Gulf of Mexico, then the traffickers would travel between Mexico and Cuba (Yucatan Channel) directly into the Gulf of Mexico. If the traffickers want to travel directly into the Bahamas, they would traverse the strait between Cuba and Haiti (Windward Pass). The third route is further east between the Dominican Republic and Puerto Rico (Mona Pass). The eastern most route is between Puerto Rico and the Lesser Antilles (Argada Pass). The USCG refers to these passes as "choke points" since the traffickers are forced to sail through them before they reach U.S. shores. Therefore, the USCG concentrates air and sea patrols in these areas.

This LE/MI scenario can be broken down into three USCG functional areas. These are to detect, monitor, and interdict the suspect vessel. Each functional area is described in more detail in the following sections.

5.2.1.1 Traffic Detection

The Caribbean and adjacent maritime regions are routinely patrolled by USCG counter-narcotic assets. USCG assets are concentrated in Jordan Knoll, Cal Sal Bank, and the Mona, Anegada, Windward, and Yucatan Passes. Currently, the USCG uses land-based aircraft and cutter-based aircraft to search these regions. All traffic within the search area is detected either visually or by radar. The vessel registration number and name is also determined, usually by visual means. This identification of the vessel is typically made during a low pass (65 m altitude) over the vessel.

Standard sighting reports are completed by the aircraft crew once a vessel has been identified. If onscene communications have been established between the patrolling aircraft and the cutter, then an abbreviated sighting report is transmitted by voice to the cutter. Upon completion of the patrol, the aircraft crew sends a completed sighting report to the on-scene cutter, the operational commander, and to the applicable databases. Using the information collected, along with any intelligence information obtained from outside sources, the operational commander/onscene cutter determines which vessels should be further investigated.

Occasionally, the USCG obtains enough intelligence information to allow for "sting" operations. In cases like these, the initial location and identification of the suspected vessel may not be obtained from the routine USCG patrols. During these operations, the aircraft must be able to covertly locate and monitor the vessels. If the vessel suspects that it is being followed, the crew may destroy the evidence, thus avoiding interdiction by USCG assets.

5.2.1.2 Suspect Vessel Monitoring

Once the USCG determines a vessel is a possible suspect, that vessel must be relocated, if necessary, and monitored. The USCG uses air assets primarily for this aspect of the LE/MI mission. Often, some delay exists from the initial detection of the vessel to the decision to monitor the vessel. This delay can be in excess of 24 hours if, during the patrol, aircraft communication with the cutter cannot be maintained. When this occurs, the aircraft must wait until it has landed before reporting the vessel sightings. While monitoring the suspect, the aircraft vectors the nearest

cutter toward the vessel. Covert operations at this point are desirable. Once the USCG presence is detected, delays in subsequent LE actions give the traffickers a chance to jettison the load and possibly avoid arrest or seizure.

5.2.1.3 Vessel Interdiction

If suspicions are aroused or confirmed, the cutter commander makes the decision to board the vessel. Cutter crews are completely responsible for boarding the vessel and interdicting the traffickers. USCG boarding teams (comprised of members from the cutter crew) perform this phase. A derivative of this concept is the Law Enforcement Detachment (LEDET), which are trained USCG boarding personnel who deploy on U.S. Navy ships engaged in counternarcotic missions. The DoD assets provide the detection and monitoring capabilities while the LEDETs accomplish the interdiction aspects of the mission. When a vessel is boarded, USCG boarding teams use a small boat to maneuver alongside the suspect vessel to board and take appropriate law enforcement action.

5.2.2 LE/MI Measures of Effectiveness/Measures of Performance

The LE/MI functional areas are illustrated in Figure 5-9 as a flow chart with the items that influence each functional area and are the analysis measures. Since there are very few mission oriented MOEs associated with the LE/MI mission, MOPs will also be evaluated. MOPs for all of the baseline aircraft and the V-22 will be compared with the known performance requirements of this mission. Also, MOEs will be compared among all of the aircraft alternatives.

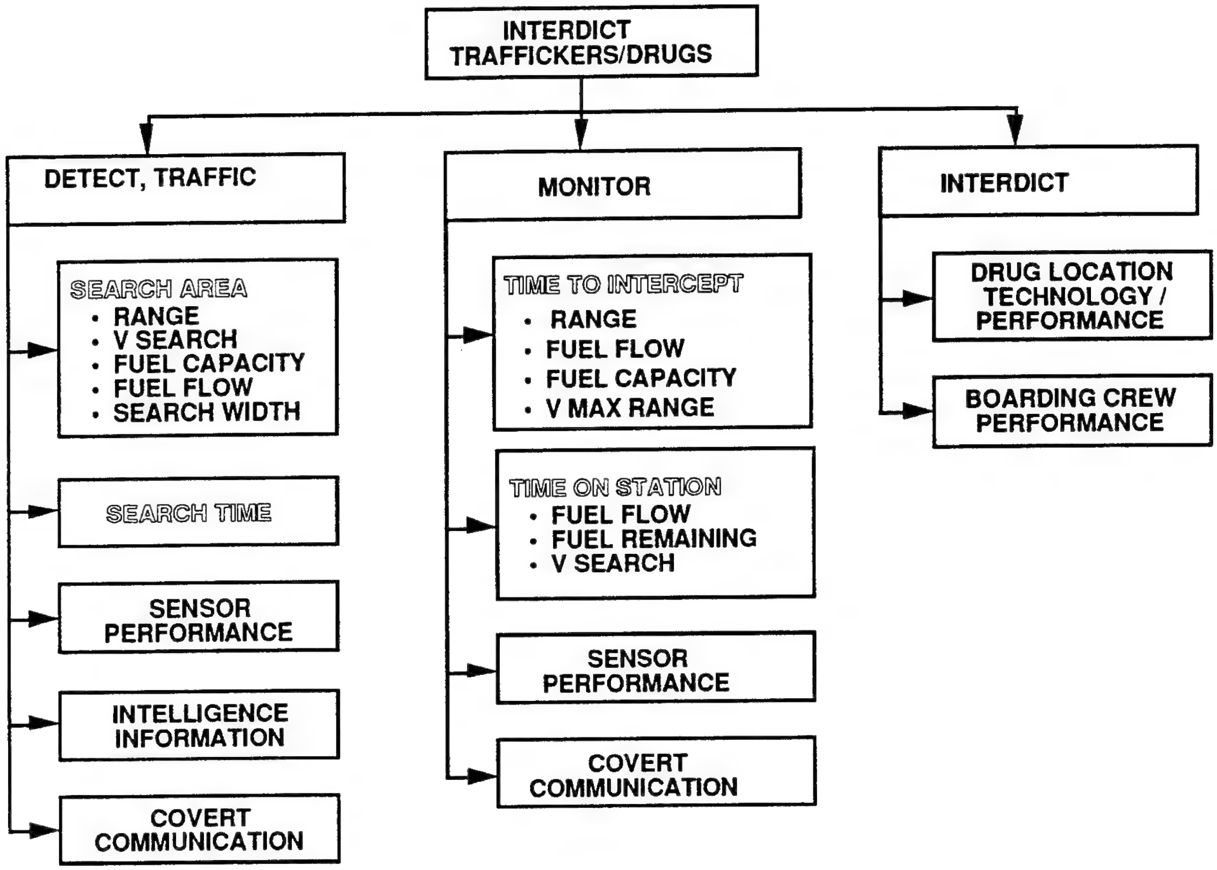


Figure 5-9 - LE/MI Functional Area Flow Chart

Detecting vessel traffic depends on five key elements. These elements are the area the aircraft can search, the amount of time spent searching, the performance of the sensors used for searching, the capabilities of the communications system to inform the USCG cutter of the vessel traffic, and the accuracy of any intelligence information. The search area is a function of the distance to the search area, the aircraft search velocity, fuel flow, fuel capacity, and search width, i.e., the width an aircraft can search with one pass. For this analysis, all of these factors are held constant except the range to the search area, which is varied from 100 to 800 km. These ranges accommodate an aircraft departing from either Miami, Cuba, or Puerto Rico and flying to the four choke points. Since this study is an analysis of platform capabilities, sensor and communication system performance is assumed to be equal for all aircraft, i.e., sensor and communication system performance is not evaluated. Similarly, the accuracy of the intelligence information is not examined.

Monitoring the suspect vessel is a function of the time required to intercept the target, the time that the aircraft can remain with the vessel (time on station), the aircraft sensor performance,

and the covert communications capability. The two factors that are examined are the intercept time and the time on station. Both factors depend on the aircraft velocity, fuel flow rates, and fuel capacity. These values are determined for each aircraft and are held constant throughout the analysis. Additionally, the time to intercept depends on the distance that the aircraft must travel to intercept the suspect vessel. This distance is varied from 100 to 800 km.

The final functional area is interdiction. This area is directly related to the quality of intelligence and the performance of the USCG boarding crews and equipment. Since these factors are not related to aircraft capabilities or performance, they are not examined in this analysis.

To summarize, several measures included in Figure 5-9 will not be used for this analysis for two reasons. Those measures not considered are either not a function of the aircraft performing the mission or reflect sensor performance which was assumed, for this analysis, to be the equivalent for both the V-22 and the baseline aircraft. Table 5-3 shows the measures that will be analyzed for this analysis.

Table 5-3 - LE/MI Functional Area MOE/MOP

Functional Area	Analysis Measures
Traffic Detection	• Search area (required 206 to 206,000 km^2)
Vessel Monitoring	• Time to intercept the vessel
	• Time on station

5.2.3 LE/MI Analysis Methodology

The measures listed in Table 5-3 are used to determine the operational effectiveness of the tiltrotor technology, as represented by the V-22, compared with the baseline USCG aircraft in the LE/MI scenario.

The first step is to gather the performance values for all of the alternative aircraft. The aircraft performance values used in the LE/MI analysis calculations are listed in Table 5-4. These values are extracted from the aircraft flight and USCG policies and procedures (Appendix A).

Table 5-4 - LE/MI Analysis Data Input

Constant Data	Aircraft Alternatives Performance					
	V-22	V-22/JSAFT	HC-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	575	237	1166
TOS fuel flow (kg/hr)	1007	1066	1752	413	191	510
Total usable fuel (kg)	5835	7583	28531	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warmup fuel (kg)	45	45	454	64	45	221
Mission fuel (kg)	5392	7129	26162	2694	730	3441
Search velocity (km/hr)	334	334	334	167	167	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	167	167	334
Sweep width (km)	29.6	29.6	29.6	32.4	32.4	29.6

This LE/MI analysis is based on the assumptions listed below.

1. The aircraft used in monitoring the vessels is not the same aircraft used to relocate the suspect vessel. The aircraft for both phases are assumed to have a full fuel load at mission start.

2. The aircraft launch from air stations in Miami, Guantanamo, and Borinquen.

3. Aircraft effectiveness when assigned to a USCG cutter is not specifically examined in this analysis. The HH-60J and HH-65A are the only aircraft alternatives that can be operated from a cutter. The V-22 is assumed to be incompatible with operations aboard a cutter.

4. The visual sweep width data obtained from the National SAR Manual tables are based on a search altitude of 457 m, visibility of 28 km, and a ship target between 27 and 46 m in length.

5. Crew composition is assumed to be not a factor in visually detecting the target.

6. Refueling is not considered.

7. The outbound distance used is the same as the return distance.

For a complete set of the equations used in the LE/MI scenario, refer to Appendix B.2. The first calculations are to determine the maximum search area and the search time. Necessary aircraft performance data are listed in Table 5-4. The time and the fuel required to fly enroute to the search area were calculated. The distances traveled from takeoff to search area are varied from 100 to 800 km. These distances cover an aircraft taking-off from Miami, Cuba, or Puerto Rico and flying to all four choke points. The fuel remaining is calculated for the aircraft to perform the search. From the search fuel, the time remaining for the search and the maximum area that can be searched in this time is calculated. Finally, the total mission time to search the area is determined. The search area can be as large as 206,000 km^2 per day. The maximum instantaneous coverage is 167 km by 222 km (approximately 38,000 km^2). Three such areas must be monitored at least 16 hours per day, 7 days per week.

Once the search area calculations are completed, the analysis on the monitor phase of the LE/MI scenario can begin by calculating the time required to intercept the targeted vessel and the time on station, i.e., the amount of time that the aircraft can monitor the vessel. Again, the aircraft performance data necessary may be obtained from Figure 5-4 so that the time and the fuel required to fly enroute to the vessel may be calculated. For the monitor phase, the distances traveled from takeoff to the suspect vessel are varied from 100 to 800 km. Once the enroute fuel is determined, the fuel remaining for the time on station over the vessel is calculated. Using the time on station fuel, the time remaining for the time on station phase is determined. Finally, the total monitor phase mission time can be calculated by combining the enroute time and the time on station.

5.2.4 LE/MI Analysis Results

The analysis results for the LE/MI scenario are presented in the areas of detection and monitoring. The following sections discuss these results and summarizes the utility of the V-22 in the LE/MI mission. For a complete listing of the raw data generated from the analysis refer to Appendix B.2.

5.2.4.1 Detection Phase

For the LE/MI scenario, detecting the vessel traffic that travels through the choke points in the Caribbean and the Gulf of Mexico is primarily a function of the airspace the aircraft can search and the time that the aircraft can remain in the search. The USCG requirement for this LE/MI mission is described in paragraph 5.2.3. At a distance of 100 km from the search area, only the fixed-wing aircraft meet the 38,000 km^2 search area standard with a single aircraft. The HH-60 and HH-65 require 2 and 3 aircraft, respectively, to satisfy this standard. As illustrated in Figure 5-10, the search area covered varies greatly with each aircraft alternative.

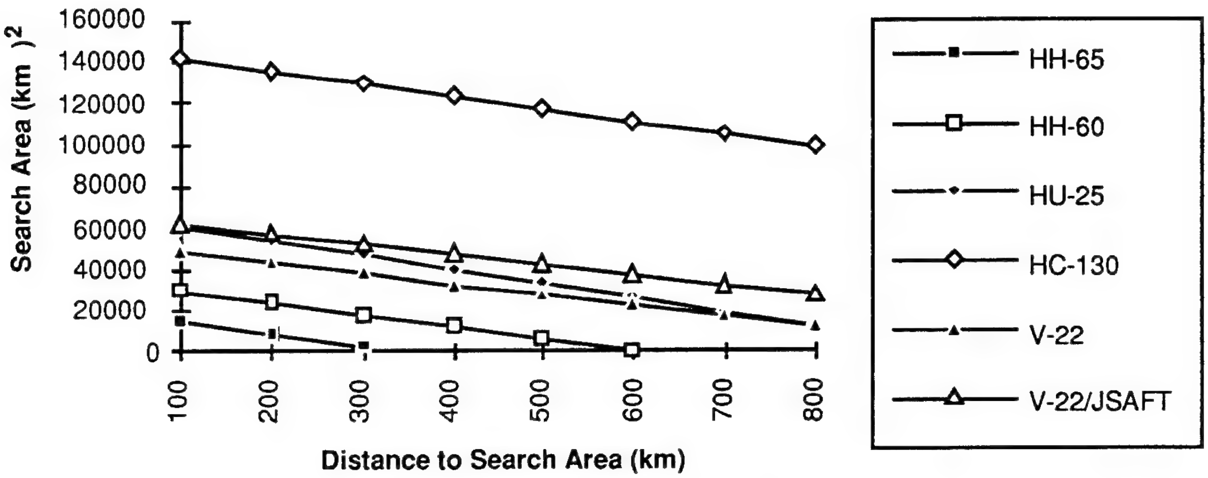


Figure 5-10 - LE/MI Search Area

Figure 5-10 plots the search area as a function of the range to the search area. The HC-130 far exceeds the search area capabilities of the other aircraft alternatives. After traveling a distance of 100 km to reach the search area, the HC-130 can search a total of 141,643 km^2. The aircraft with the next highest performance is the V-22 with one JSAFT which can search 61,311 km^2. The HU-25 and the V-22 can search 60,028 km^2 and 47,959 km^2, respectively. For land-based helicopters transiting 100 km to the search area, the HH-60 can search 29,490 km^2 and the HH-65 can search 14,900 km^2. However, one should note that the HH-65 may be deployed aboard Bear, Hamilton, and 210-class cutters and the HH-60 may be deployed aboard the Bear and Hamilton cutters. While such operations significantly reduce the transit distance to the search area, review of the USCG 1992 Abstract of Operations suggests that only approximately 10% of HH-65 flight hours are from cutter deployed aircraft. The HH-60 induction into fleet operations is too recent to make any observations other than the number of HH-60 compatible cutter decks, i.e., 25, is substantially less that for the HH-65, i.e., 41. As the distance to the search area increases, the airspace that each aircraft can search also decreases. The relative performance order of the

alternatives remains constant at these greater ranges. Figure 5-11 illustrates the number of hours spent conducting searches in the areas shown in Figure 5-10.

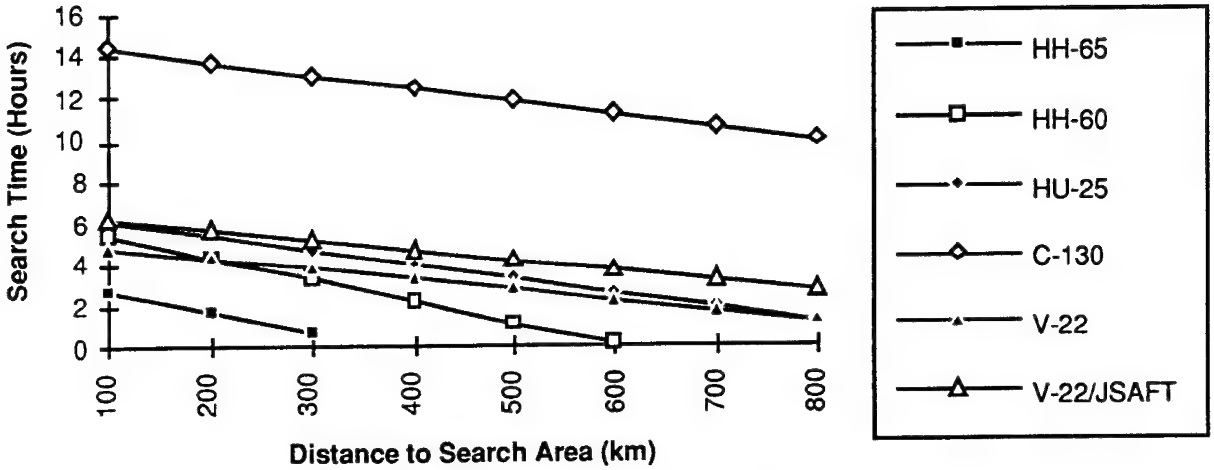


Figure 5-11 - LE/MI Search Time

5.2.4.2 Monitoring Phase

Monitoring a vessel that has been identified as a possible suspect requires an aircraft that can intercept the vessel quickly and remain on station for extended periods of time to vector the USCG cutter toward the suspected trafficker. Figure 5-12 charts the intercept times for all of the aircraft alternatives as a function of the range to the suspect vessel. These results directly reflect the velocity used to intercept the target. For this analysis, the aircraft flew at best cruise airspeed, i.e., 99% best range velocity, so that fuel could be conserved to remain on station for as long as possible. At these velocities, all of the fixed-wing aircraft alternatives intercept the suspected vessel at 800 km in approximately 1.75 hours

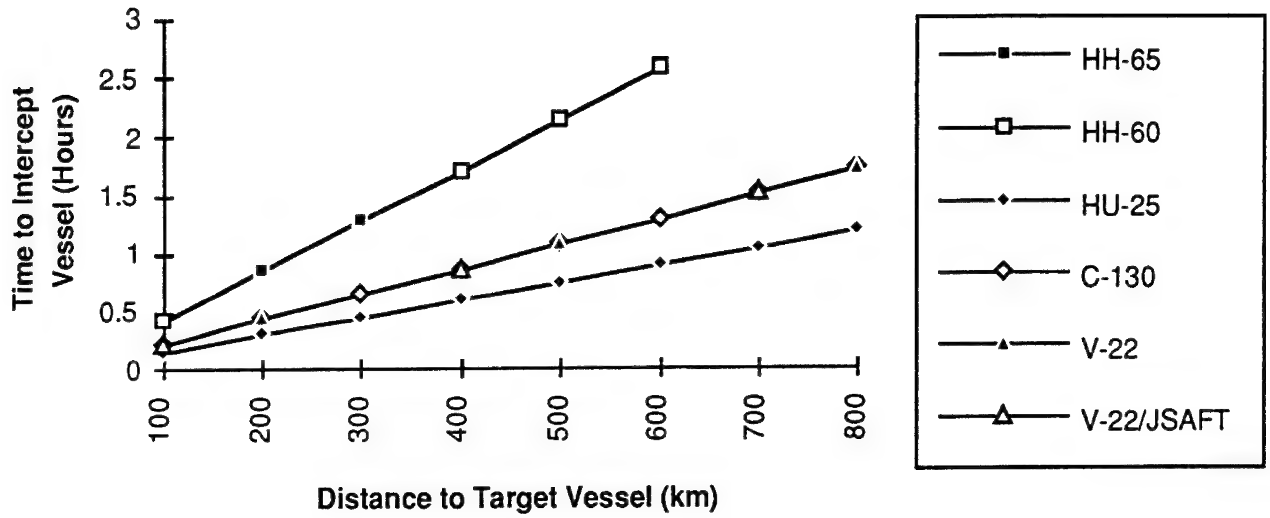


Figure 5-12 - LE/MI Time to Intercept Target Vessel

Figure 5-13 illustrates the time on station (TOS) over the suspect vessel. Time on station is plotted as a function of the distance flown before reaching the suspect vessel. At a distance of 100 km, the HC-130 can remain on station for 14.3 hours. The next closest performer is the V-22 with the JSAFT which can stay with the vessel for 6.2 hours. Time on station for the HU-25, HH-60, V-22 and the HH-65 are 6.1 hours, 5.5 hours, 4.8 hours, and 2.8 hour respectively. As the range to the suspect vessel increases, the relative order of the alternatives remains unchanged, except that the order of the HH-60J and V-22 is reversed. At longer ranges, the greater fuel capacity and enroute velocity of the V-22 provide a longer time on station than for the HH-60J.

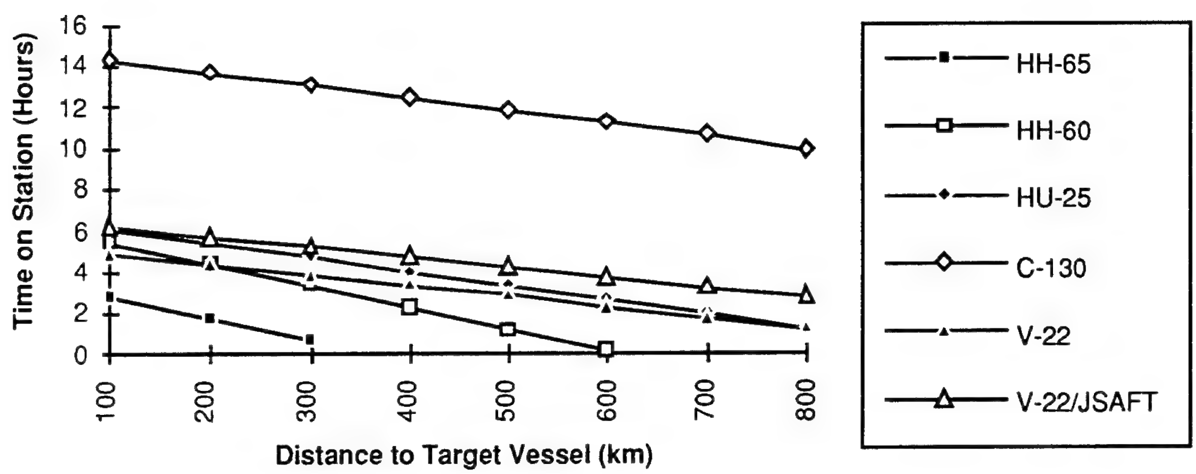


Figure 5-13 - LE/MI Time On Station (TOS)

5.2.4.3 LE/MI Analysis Summary

The operational effectiveness of USCG assets in the LE/MI scenario is a function of the area the aircraft can search in order to detect the vessel traffic, the time on station devoted to monitoring the suspect vessel, and the time to intercept a suspect vessel. The extensive fuel capacity of the HC-130H provides a significant advantage over all other alternatives in size of the search area and time on station. The V-22 with JSAFT holds a similar advantage. The baseline V-22 is nearly as effective as the HU-25 and significantly more effective than the helicopter alternatives. While the speed of the HU-25 provides an advantage in time to intercept a vessel suspected of trafficking illegal drugs, this advantage is less critical in the LE/MI mission due to the slow speed of the target. The high speed of fixed-wing aircraft may also be a disadvantage in the tracking phase due to the difficulty in holding a visual track on a slow surface target. The V-22 capability to convert from fixed-wing to an optimum nacelle-angle for station-keeping may provide an advantage in this phase of the mission without a significant degradation in time on station.

Within the scope of this study, the application of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of enforcement of the laws of the United States, especially with respect to drug interdiction, offers an operational effectiveness equal to or better than most of the baseline systems.

5.3 Marine Environment Protection (MEP)

The Marine Environmental Protection (MEP) program has three key objectives. These are to minimize the damage caused by pollutants released in the coastal zone; to overcome or reduce threats to marine environments posed by potential spills of oil or other hazardous substances; and to assist in national and international pollution response planning efforts. The MEP program is regulated by the Federal Water Pollution Control Act (the "Clean Water Act") of 1972 and its amendments. Under this plan, the USCG has been designated as the lead agency to respond to the threat of pollution in the coastal zone and in specified ports on America's inland river system.

The MEP program has varied requirements across its mission areas. Some of the functions for which the MEP program is responsible are listed on the following page. This analysis concentrates on the incident response function only.

- Patrol for Deterrence and Enforcement - The primary objectives of this mission are to deter maritime pollution and to identify and successfully prosecute those guilty of polluting the marine environment.

- Oversight and Enforcement of Regulated Dumping Activities - This mission includes the monitoring of legal dumping and the detection of illegal dumping.

- Incident Response - The primary objective of this mission is to respond to an oil spill incident in a timely manner and provide the on-scene units with the information and expertise required to combat the spill.

5.3.1 MEP Incident Response Scenario Definition

The primary objective of the MEP incidence response scenario is to respond to an oil or chemical spill incident in a timely manner and to provide the on-scene units with the information required to combat the spill including the extent of the spill; the quantity, distribution, and movement of the oil; and the environmental data required to predict the movement of the slick. For this scenario, the USCG will also participate in the spill containment activities utilizing USCG Marine Safety Office (MSO) and National Strike Force (NSF) assets. This mission differs from previous missions in that no patrol activity is required to detect the incident. The pollution sightings are reported to the National Response Center. The report is then forwarded to the local MSO for further investigation.

The MEP scenario evaluated in this analysis is a response to an oil spill incident. Table 5-5 shows the number and type of incidents that the NSF Coordination Center and the Strike Teams responded to during 1992. From these data, as illustrated in Figure 5-14, 37% of the incidents that the NSF responded to were oil spills, and an additional 18% of the responses had the potential to become an oil spill. Most of the incidents to which the NSF responded were related to oil.

Table 5-5 - 1992 NSF Coordination Center and Strike Team Response

NSF Division	Oil Spill	Oil Potential	Chemical Spill	Chemical Potential	Other	Total
NSF Coordination Center (NSFCC)	4	0	0	0	0	4
Atlantic Strike Team (AST)	13	7	8	10	2	40
Gulf Strike Team (GST)	23	11	10	8	1	53
Pacific Strike Team (PST)	13	8	20	5	2	48
Total	53	26	38	23	5	145

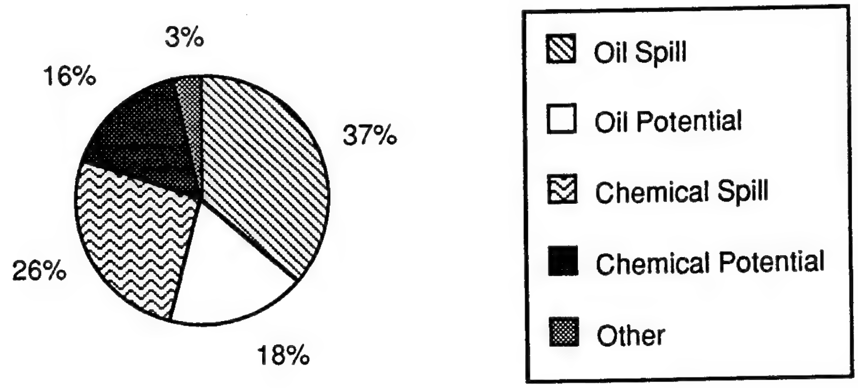


Figure 5-14 - Total 1992 NSF Response

The USCG role in this scenario is to assist in the mapping, monitoring, and containment of the oil spill. An overview of the MEP oil spill incidence response scenario is depicted in Figure 5-15. Upon notification of an oil spill, the NSF assigns the appropriate personnel and equipment and transports them to the spill site. The USCG is also responsible for gathering information about the oil slick which will aid the containment process.

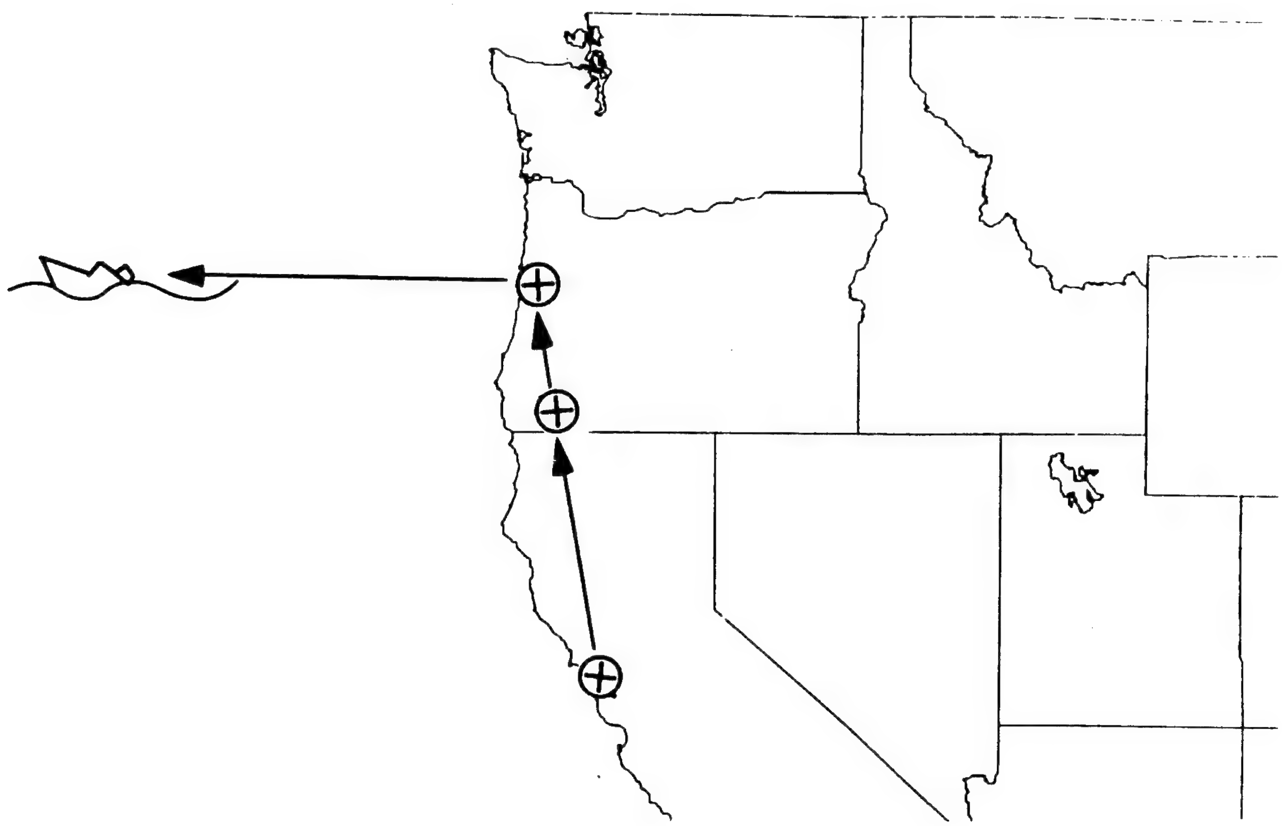


Figure 5-15 - MEP Oil Spill Incident Response Scenario

This MEP scenario can be broken down into four USCG functional areas, i.e., initial NSF response, equipment transportation , oil slick monitoring , and spill containment. Each functional area is described in more detail in the following sections.

5.3.1.1 Initial NSF Response

When an oil spill has been detected, the Marine Safety Office is notified and, in turn, notifies the appropriate Strike Team for incident verification and assessment. For instance, for an oil spill occurring in Alaska, the Pacific Strike team would be notified to assess the situation. First, the strike team accesses the Response Resource Inventory (RRI) data base to gain information on the availability and locations of equipment, personnel, aircraft, and DoD and industry assets. Any particular handling and transportation requirements for the equipment are also listed. Next, the strike team sends a two-person crew to the site to assess the spill, to determine the amount and type of equipment required to contain the spill, to organize the off-loading of the equipment to the staging area and to the spill site, and to begin the coordination necessary between the on-scene coordinator and the USCG. After the situation has been assessed, the strike team

5.3.1.2 Equipment Transportation

Although equipment has been pre-positioned at nineteen sites around the Nation, the scenario is concerned with the required equipment which must be transported from the strike force storage facilities to the spill site. Currently, the equipment is loaded onto HC-130H aircraft, transported to a staging area, loaded onto tractor-trailers, and finally transported to the spill site. The staging area is the runway closest to the spill site where a HC-130H can land. HC-130H aircraft are used to transport the equipment from the storage facilities to the staging area for two reasons. First, the equipment is palletized to fit onto the HC-130H for fast loading and offloading capabilities. Secondly, the HC-130H has the extended ranges that are required to transport the equipment to a staging area that is close to the spill site. The first load of equipment and personnel are required to begin to travel toward the staging area within four hours of the response notification. For this analysis, the HC-130H and the V-22 are the only aircraft examined for transporting the equipment to the staging area. The other baseline aircraft do not have sufficient cargo capacity or range to carry this equipment.

The landing requirements of the HC-130H occasionally dictate that the equipment be transported to a staging area that is distant from the actual spill. Currently, the equipment is transported to the site (or the port closest to the spill site) using tractor-trailers and boats if possible. These assets may be borrowed from the US Navy Supervisor of Salvage, DoD transportation commands, and industry. The RRI data base will pinpoint the availability of these assets.

5.3.1.3 Oil Slick Monitoring

USCG air assets are used to monitor the oil slick to determine the location, relative thickness and consistency of the slick, slick drift, and the surface currents of the water. This information is obtained through visual sightings by airborne observes, sensors and, occasionally, by taking samples of the oil from a helicopter. This information is passed on to the on-scene coordinator to help make decisions about containing the oil slick.

5.3.1.4 Spill Containment

After the equipment is transported to the spill site (or the closest port to the site), it must be assembled, deployed in the water, and operated. Generally, USCG aircraft assets are not used during this phase although helicopters are occasionally used to sling load pieces of equipment to some offshore or remote locations.

5.3.2 MEP Measures of Effectiveness/Measures of Performance

The oil spill incidence response functional areas are illustrated in Figure 5-16 as a flow chart with the items that influence each functional area. These items will become the analysis measures. Since there are very few mission oriented MOEs associated with the MEP mission, MOPs will also be evaluated. MOPs for all baseline aircraft and the V-22 will be compared with known performance requirements of this mission. Also, MOEs will be compared between the baseline aircraft and the V-22.

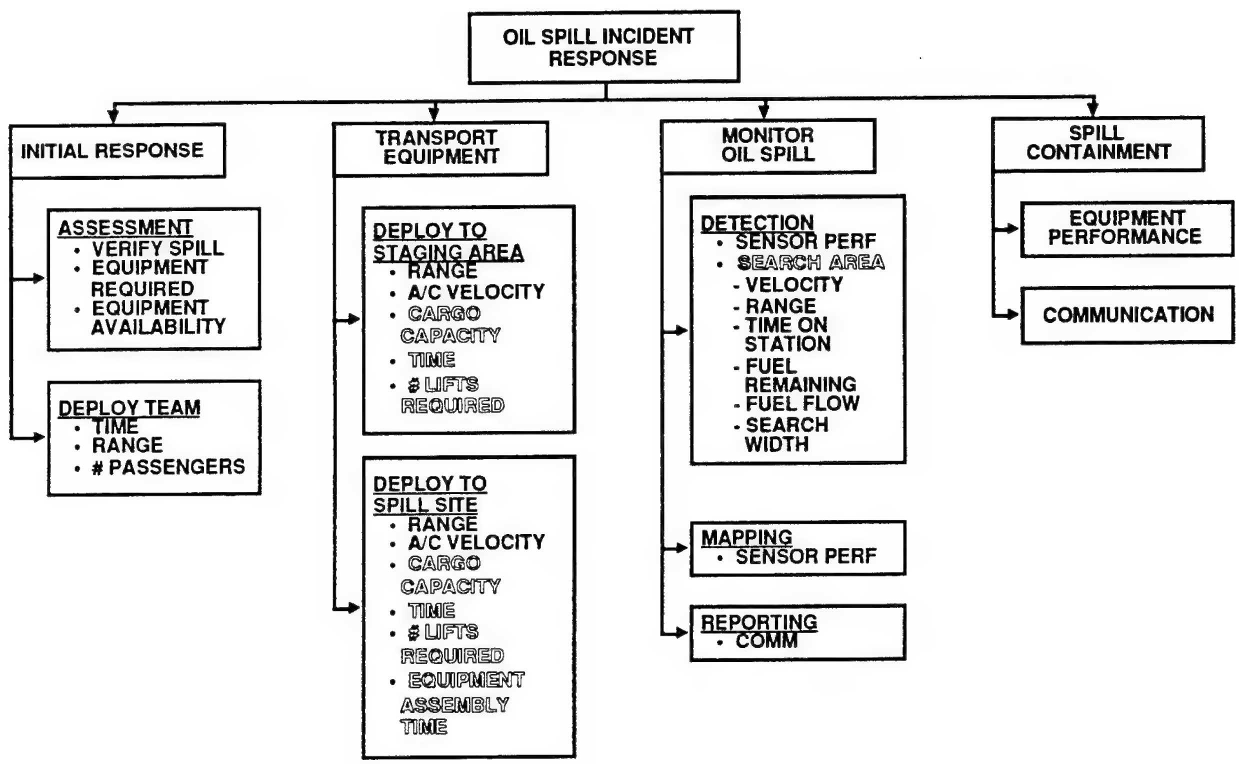


Figure 5-16 - MEP Oil Spill Functional Area Flow Chart

The items that influence the initial response functional area deal with the assessment of the oil spill and with the deployment of the strike force team. These items do not show the utility of

the V-22 relative to the baseline aircraft. Therefore, no analysis measures will be used from this functional area.

The functional area of transporting equipment can be divided into the two segments of deployment of the equipment to the staging area and deployment of the equipment to the spill site. Deploying the equipment to the staging area is a function of several items, e.g., the range to the staging area; the velocity, fuel capacity, and fuel flow of the aircraft carrying the equipment; the amount of equipment that the aircraft can either carry or hoist; the number of lifts required to transport the equipment to the staging area; and the time that is required to transport the equipment. The measures that will be an output of this analysis are the cargo capacity of the aircraft, the time required to transport the aircraft, and the number of lifts required. The distance to the staging area will be varied from 400 to 2000 km. The other elements are performance measures which will be held constant throughout the analysis.

Deployment of equipment to the spill site is a function of the same elements as deploying the equipment to the staging area with the addition of the time required to assemble and deploy the equipment. For this analysis, the time required to assemble the equipment is assumed to be constant for all aircraft alternatives. Even though the equipment may have to be packaged differently to accommodate the different sizes/carrying capabilities of the alternative aircraft, the total amount of time assembling the equipment should remain relatively constant. Where the differences occur is the amount of time spent in loading and unloading the various aircraft. For this analysis, this time is also assumed to be constant for all aircraft alternatives.

Monitoring the oil spill is a function of the detection, mapping, and reporting capabilities of the aircraft. The detection of the oil spill relies on several elements, e.g., the aircraft sensor performance (both sensors and the human eye are used) and the search area that the aircraft can cover. For this analysis, the sensor performance is assumed equal for all aircraft alternatives. However, the different sensor suites are included in the cost estimates and analysis. The search area is a function of the aircraft velocity, range to the search area, time searching, amount of fuel remaining, the fuel flow, and the search width, i.e., the width that the aircraft can search with one pass. All of these items are held constant throughout the analysis except for the range to the search area which is varied from 50 to 250 km. This distance covers a majority of the cases except for some of the extreme conditions in Alaska.

Mapping the oil spill is a function of the aircraft sensor performance and reporting the spill to the on-scene coordinator is a function of the communication systems onboard. For this analysis, the sensor/equipment performance is assumed equal for all aircraft alternatives.

The final functional area is the containment of the oil spill. This area is directly related to the performance of the containment equipment and the cleanup crews deployed to the scene, and the performance of the communication systems linking the crews and the on-scene coordinator. These measures show the effectiveness of the USCG; however, they are not related to aircraft capabilities or performance. Therefore, they are not considered for this analysis.

Table 5-6 presents the measures that will be used for this analysis.

Table 5-6 - MEP Functional Area MOE/MOP

Functional Area	Analysis Measures
Equipment transportation to staging area	• Time to transport equipment to the staging area • Number of lifts required to transport equipment • Cargo capacity
Equipment transportation to spill site	• Time to transport equipment to the spill site • Number of lifts required to transport equipment • Cargo capacity • Time to assemble equipment
Oil slick monitoring	• Search area covered (requirement is 13736 km^2) • Search area coverage rate (requirement is 6868 km^2/hour)

5.3.3 MEP Analysis Methodology

The measures listed in Table 5-7 were used to determine the operational effectiveness of the tiltrotor technology, as represented by the V-22, compared with the baseline USCG aircraft in the MEP scenario. An outline of the methodology used to calculate these measures follows.

The aircraft performance values used in the analysis calculations are listed in Table 5-7. These values are extracted from the aircraft flight manuals and USCG policies and procedures. (Appendix A).

Table 5-7 - MEP Analysis Input Data

Constant Data	Aircraft Alternatives Performance						
	V-22	V-22/JSAFT	HC-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21542 VTO/24943 STO		70308	9927	4037	14515	28123
Cargo bay dimensions (m)	7.4x1.8x 1.8	3.7x1.8x1.8	12.5x3x3	-	-	-	12.2x2.4
Max cargo weight (kg)	9072	7324	18144	-	-	-	22680
Max external cargo weight (kg)	6804 dual point 4535 single point		-	2722	907	-	-
# lifts for MEP equip	12	12	5	-	-	-	4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	-
Enroute fuel flow (kg/hr)	1193	1225	2554	575	237	1166	15.4
Loaded fuel flow (kg/hr)	1686	1686	2346	-	-	-	15.4
Total useable fuel (kg)	5835	7583	28531	2930	854	4536	154
Landing fuel (kg)	398	409	1916	172	79	874	-
Start/warm-up fuel (kg)	45	45	454	64	45	221	-
Mission fuel (kg)	5292	7129	26161	2694	730	3441	154
Search velocity (km/hr)	334	334	334	167	167	334	-
Enroute velocity (km/hr)	463	463	463	233	233	667	89
Loaded velocity (km/hr)	380	380	393	-	-	-	89
Max dist to stage (km)	657	166	3507	-	-	-	886
Max dist to spill (km)	328	83	1754	-	-	-	443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	-

This analysis is based on the assumptions listed below. These assumptions are in addition to the study-wide assumptions listed in Section 3.0.

1. For simplicity, the aircraft used in monitoring the oil slick are different from those used to transport the MEP equipment. Aircraft for both phases are assumed to have full fuel loads at mission start.

2. One lift sortie constitutes a round trip to and from the staging area or spill area.

3. The time required to load and unload the equipment is considered where the V-22 is compared to the combination of the HC-130H and the tractor-trailer in transporting the MEP equipment from the storage site directly to the spill site. For this analysis, two hours is used as the time to unload the HC-130H and load the tractor-trailer. The time to load at the storage site and unload at the spill site is assumed to be equal for both methods.

4. The usual sweep width data obtained from the National SAR Manual are for a search altitude of 457 m, visibility of 9 km, and a target longer than 92 m.

5. Crew composition is assumed not to be a factor in visually detecting the target.

6. Refueling is not considered.

7. The outbound distance is assumed to be equal to the return distance.

For a complete set of the equations used in the MEP scenario, refer to Appendix B.3. The cargo capacity of the aircraft alternatives was determined initially by considering the dimensions of the cargo bay, the external load, and the weight limits of the transporting aircraft and tractor-trailers (for overland transportation to the spill site). These cargo capacities were then compared with the dimensions and the weights of the MEP equipment to determine the equipment which could be carried on all of the aircraft alternatives and the tractor-trailers. For the vehicles that could transport the MEP equipment, the number of lifts required to carry all of the equipment is calculated.

The number of lifts required to carry all of the equipment is significant in determining the time required to transport the equipment from the strike force location to the staging area. The first step is to obtain the aircraft performance data necessary from Figure 5-7. These data may be used to calculate the time required to transport one load of the equipment to the staging area. The distances traveled from the strike team location to the staging area are varied from 400 to 2000 km. Combining the single load time with the number of lifts required to carry all of the equipment, the time required to transport all of the equipment to the staging area can be calculated.

The number of lifts required to carry all of the equipment is also significant in determining the time required to transport the equipment from the staging area to the spill site. Data from Figure 5-7 are used to calculate the time required to transport one load of the equipment to the spill site. The distances traveled from the staging area to the spill site are varied from 50 to 250 km. Combining the single load time with the number of lifts required to carry all of the equipment, the time required to transport all of the equipment to the staging area is calculated.

The maximum area that each aircraft can monitor and the time taken to monitor that area may be calculated using aircraft performance data from Figure 5-7. The time and the fuel required to fly enroute to the oil slick is then calculated. In this analysis, the distances traveled from takeoff to the oil slick are varied from 20 to 100 km. The fuel consumed enroute is used to calculate the

fuel remaining for monitoring the oil slick. From the fuel available to monitor the slick, the time remaining to monitor and the maximum area that can be monitored in this time may be calculated. Finally, the total mission time to monitor the oil slick is determined.

5.3.4 MEP Analysis Results

The analysis results for the MEP scenario are presented in four areas, i.e., cargo capacity, transportation to the staging area, transportation to the spill site, and monitoring of the oil slick. The following sections discuss these results and summarizes the utility of the V-22 in the MEP function. Refer to Appendix B.3 for a complete listing of the MEP results.

5.3.4.1 Cargo Capacity

Currently, the primary USCG aircraft asset used to transport the equipment required for the MEP mission is the HC-130H. Generally, the HU-25 does not have the cargo capacity required to transport this equipment. Although USCG helicopters do not have the external load capacity to carry all the MEP equipment, they are occasionally used to sling load pieces of equipment to a site, such as a ship or a remote location. Also, the helicopters, generally, do not have the extended ranges that may be necessary to transport the equipment to the spill site. Therefore, this analysis concentrates on the ability of the V-22 as compared to the HC-130H to carry the equipment.

The first step in this analysis is to determine the type, weight, and dimensions of the equipment that the NSF uses to combat oil spills. A representative list of the equipment used is shown in Table 5-8. This list is separated into two main sections, i.e., the pumping equipment and the oil containment/recovery equipment.

Table 5-8 - MEP Equipment List

Equipment	Description	Weight (kg)	Dimensions (m3, mxmxm)
Pumping Equipment			
Air Deployable Anti-Pollution Transfer System (ADAPTS)	Pumping equipment, rapid deployment by HC-130, HH-3F, HH-52, trucks, and ships	1843	6.4
ADAPTS spares pallet	Spare parts for the ADAPTS	1580	
Viscous Oil Pumping System (VOPS)	Pumping equipment, rapid deployment by HC-130, trucks, and ships	3282	4.6
Double Stage Pump	Submersible pump, requires a prime mover as power source	227	0.7 (0.5x0.5x2.9)
Prime Mover - General Motors GM-4-53	Power source for all submersible pumps	1860	2.7
Gormann-Rupp Pump	Non-submersible pump, requires a prime mover as power source	143	0.5 (0.5x1.2x0.9)
Prime Mover - Avco Lycoming Type III	Power source for non-submersible pumps	748	2.3
Pumping Support Equipment	Hydraulic hose and Quick Disconnect couplings, for each 30.5 m of hose	68	0.1 per 30.5 m of hose
Pumping Support Equipment	Discharge hose and Quick Disconnect fittings, for each 15.2 m of hose	45	0.2 per 15.2 m of hose
Pumping Support Equipment	Tripod with rigging equipment which supports weight of submersible pump	79	0.3
Pumping Support Equipment	Fuel bladder (208 liter) for prime movers. Weight empty/weight filled	19/191	0.3
Pumping Support Equipment	Metering support equipment, small items	N/A	
Oil Containment and Recovery Equipment			
Open Water Oil Containment Recovery System (OWOCRS)	187 m, "high seas" barrier used to recover oil in the open sea	4990	
Air Deployable Container (ADC) box	Used to stow the OWOCRS	2268	24.8 (5.6x2.8x1.6)
Pump Float	Work boat without an engine used with the OWOCRS, requires a prime mover on another vessel	1134	9.5 (4.3x2.4x0.9)
OWOCRS Retrieval/Recovery System	Recovers the OWOCRS from the water, requires a prime mover. Retrieval rack data/recovery rack data	408 / 1588	10.3 / 48.9 (1.4x3x2.4 / 7.9x2.8x2.2)
Vessel of Opportunity Skimming System (VOSS)	Skimmer attached to ships to extract oil from the water, packaged in two containers	4990 per container	22.2 (4.3x2.4x2.1)
Portable Inflatable Collapsible Barges	Flexible tube that carries oil products and buoyancy tubes, 98410 l capacity	1136	3.8 (2.1x1.3x1.4)

Next, the cargo carrying capabilities of the HC-130H and the V-22 are determined. For deployment to the spill site calculations, the effectiveness of the V-22 is also compared with the effectiveness of a tractor-trailer. Table 5-7 lists the capabilities of these three vehicles. Comparing the capabilities of the vehicles to the size and weight of the equipment listed in Table 5-8, the HC-130H, V-22 and the tractor-trailer can carry all pieces of the equipment.

To determine the number of lifts required for each vehicle to transport all of the equipment, the weight and dimensions of each piece of equipment is examined. For the transit from the staging area to the spill site, if the dimensions of the equipment are too large to fit inside the V-22,

external loading may be considered to transport the equipment. Equipment is grouped according to its weight, volume, and function. Whenever possible, the equipment is grouped so that upon reaching the destination, the crew can begin to assemble and deploy the equipment as soon as it is unloaded. Table 5-9 lists the quantity of each equipment that is required for the analysis scenario, the weights of the equipment, and the number of lifts (including both internal and external) required for the HC-130H, the V- 22, and the tractor-trailer. For this oil spill incidence response scenario, the HC-130H requires 5 lifts to transport all of the equipment; the V-22 uses 12 lifts; and the tractor-trailer needs 4 lifts.

Table 5-9 - MEP Equipment Required For Oil Spill

<table>
<tr><th rowspan="2">Equipment</th><th rowspan="2">Number Required</th><th rowspan="2">Weight (kg)</th><th colspan="3">Number of Lifts Required</th></tr>
<tr><th>HC-130</th><th>V-22</th><th>Tractor-trailer</th></tr>
<tr><td>Air Deployable Anti-Pollution Transfer System (ADAPTS)</td><td>2</td><td>3687</td><td rowspan="3">1</td><td rowspan="2">1</td><td rowspan="5">1</td></tr>
<tr><td>ADAPTS spares pallet</td><td>2</td><td>3160</td></tr>
<tr><td>Viscous Oil Pumping System (VOPS)</td><td>2</td><td>6564</td><td>1</td></tr>
<tr><td>Prime Mover - General Motors GM-4-53</td><td>2</td><td>3720</td><td rowspan="9">1</td><td rowspan="3">1</td></tr>
<tr><td>Double Stage Pump</td><td>2</td><td>454</td></tr>
<tr><td>Prime Mover - Avco Lycoming Type III</td><td>2</td><td>1497</td><td rowspan="7">1</td></tr>
<tr><td>Gormann-Rupp Pump</td><td>2</td><td>286</td><td rowspan="6">1</td></tr>
<tr><td>Hydraulic hose/Quick Disconnect couplings, for each 30.5 m of hose</td><td>244 m</td><td>544</td></tr>
<tr><td>Discharge hose/Quick Disconnect fittings, for each 15.2 m of hose</td><td>244 m</td><td>363</td></tr>
<tr><td>Tripod with rigging equipment for submersible pumps</td><td>2</td><td>159</td></tr>
<tr><td>Fuel bladder (208 l) for prime movers, weight filled</td><td>4</td><td>762</td></tr>
<tr><td>Metering support equipment, small items</td><td>4</td><td>N/A</td></tr>
<tr><td>Open Water Oil Containment Recovery System (OWOCRS)</td><td>2</td><td>9979</td><td rowspan="3">1</td><td rowspan="2">2[1]</td><td rowspan="4">1</td></tr>
<tr><td>Air Deployable Container (ADC) box</td><td>2</td><td>4536</td></tr>
<tr><td>Pump Float</td><td>2</td><td>2268</td><td>2[2]</td></tr>
<tr><td>OWOCRS Retrieval/Recovery System</td><td>1</td><td>1996</td><td>1</td><td>1[3]</td></tr>
<tr><td>Vessel of Opportunity Skimming System (VOSS)</td><td>1</td><td>9980</td><td rowspan="2">1</td><td>2[4]</td><td rowspan="2">1</td></tr>
<tr><td>Portable Inflatable Collapsible Barge for VOSS, 98410 l capacity</td><td>2</td><td>2272</td><td>1</td></tr>
<tr><td>Total Number of Lifts</td><td>--</td><td>—</td><td>5</td><td>12</td><td>4</td></tr>
</table>

[1] The OWOCRS, as currently packaged in the ADC, is not compatible with the V-22 as either an internal or external load. However, the weight of the OWOCRS without its associated ADC would permit internal loading on the V-22. Repackaging is necessary to move the OWOCRS with the V-22.

[2] The weight of the pump float permits internal loading on the V-22. A single dimension is slightly too large to fit the V-22 cabin . However, this study assumes repackaging is possible to enable loading aboard the V-22.

[3] The weight of the OWOCRS Retrieval/Recovery System is well within the internal load limit. However, as currently packaged, this system can not be loaded aboard the V-22. This study assumes that repackaging is possible to enable such loading.

[4] The weight of each of the VOSS containers permits loading single containers aboard a V-22. Two dimensions exceed the cabin size of the V-22. However; this study assumes repackaging is possible to enable loading aboard the V-22.

5.3.4.2 Staging Area

Aircraft range, cargo capacity, and the transportation time required are important elements to consider when carrying the MEP equipment from the NSF strike team location to the staging area. Due to the size and weight of the equipment required for oil spill containment, only the HC-130H and the V-22 are capable of transporting the equipment. Figure 5-17 plots charts the round-trip time necessary for transporting a single load of equipment to the staging area as a function of the distance to the site. The V-22 requires more time to transport one load than the HC-130H; however, if the staging area is 400 km from the strike team, the transportation times are essentially equal. However, at distances greater than 650 km, the HC-130H is the only aircraft alternative that has the range to transport the equipment to the staging area.

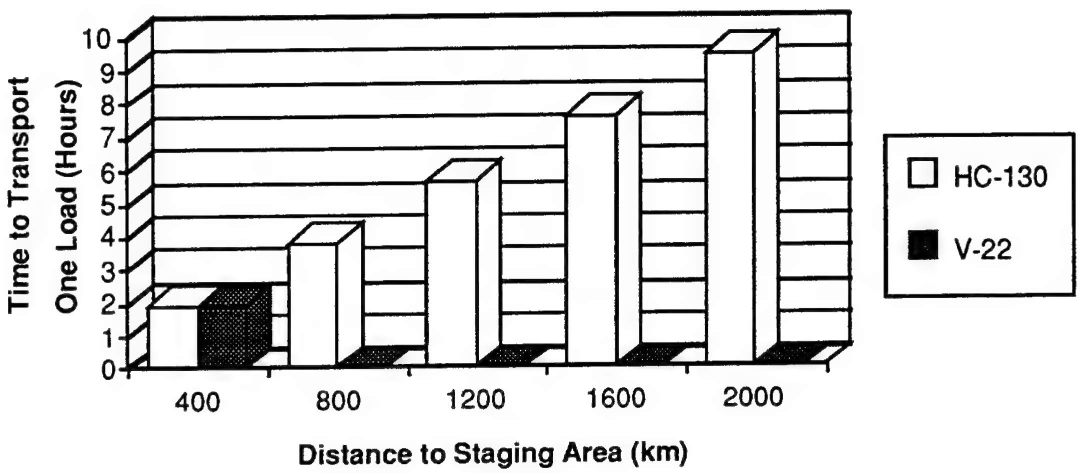


Figure 5-17 - MEP Time to Transport One Equipment Load to the Staging Area

Combining the increase in carrying a single load with the number of loads required to transport all of the MEP equipment, the HC-130H significantly outperforms the V-22 as illustrated in Figure 5-18. For example, at a transportation range of 400 km, the HC-130H can re-locate all of the equipment in 9.4 hours, while the V- 22 requires 23.0 hours.

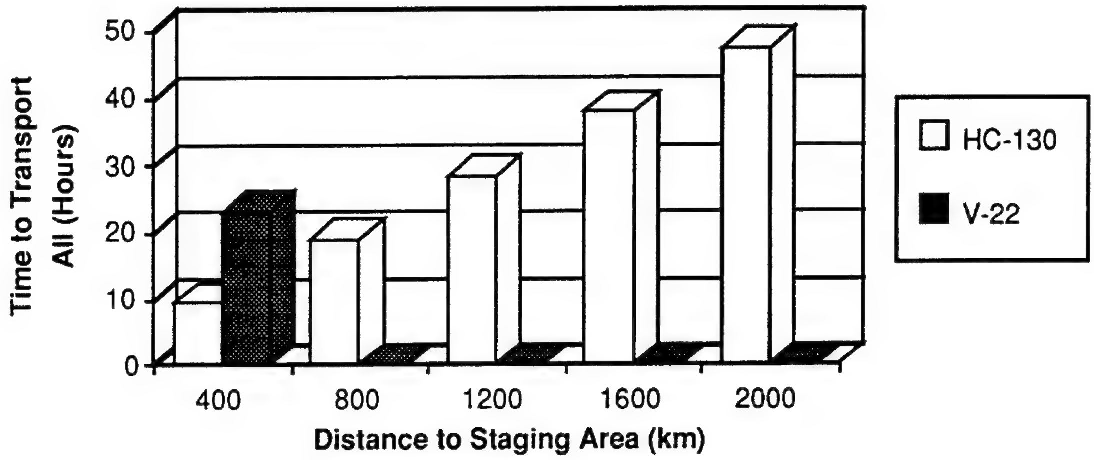


Figure 5-18 - MEP Time to Transport All Equipment to the Staging Area Using One Aircraft

5.3.4.3 Spill Site

Aircraft cargo capacity and the transportation time required are important elements to consider when carrying the MEP equipment from the staging area to the spill site. If the range from the staging area to the spill site can be assumed to be less than 250 km, it is not a significant factor in transporting the equipment to the spill site. Due to the size and weight of the equipment required for oil spill containment, only the tractor-trailer and the V-22 are capable of transporting the equipment. Figure 5-19 charts the time necessary for transporting a single load of equipment from the staging area to the spill site as a function of the distance to the site. The tractor-trailer requires significantly more time to transport one load than the V-22 for the distances examined. If the spill site is 250 km from the staging area, the V-22 saves 4.4 hours per load.

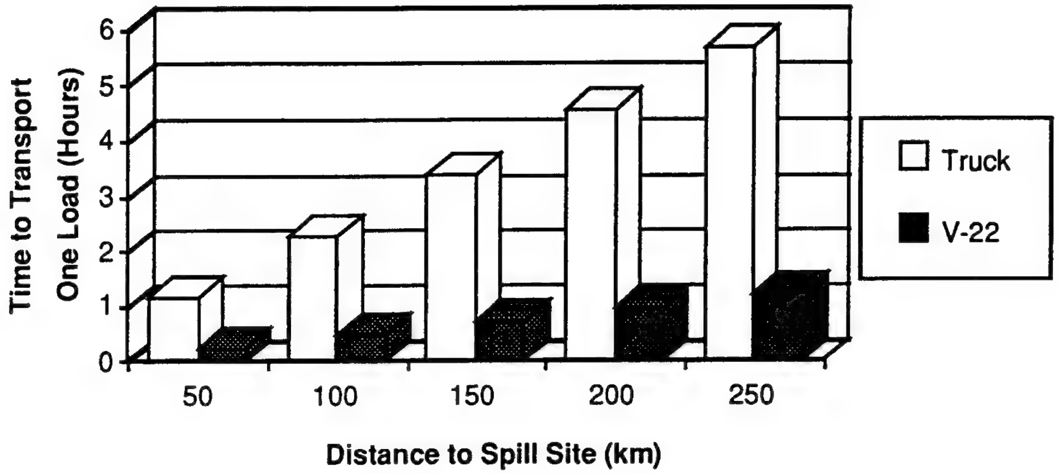


Figure 5-19 - MEP Time to Transport One Equipment Load to the Spill Site

Combining the lower time for the V-22 to carry a single load with the greater number of loads required to transport all of the MEP equipment, the V-22 transports the equipment in less time than by overland transportation. This is illustrated in Figure 5-20. For example, at a transportation range of 250 km, the V-22 can re-locate all of the equipment in 14.4 hours, while the tractor-trailer requires 22.6 hours.

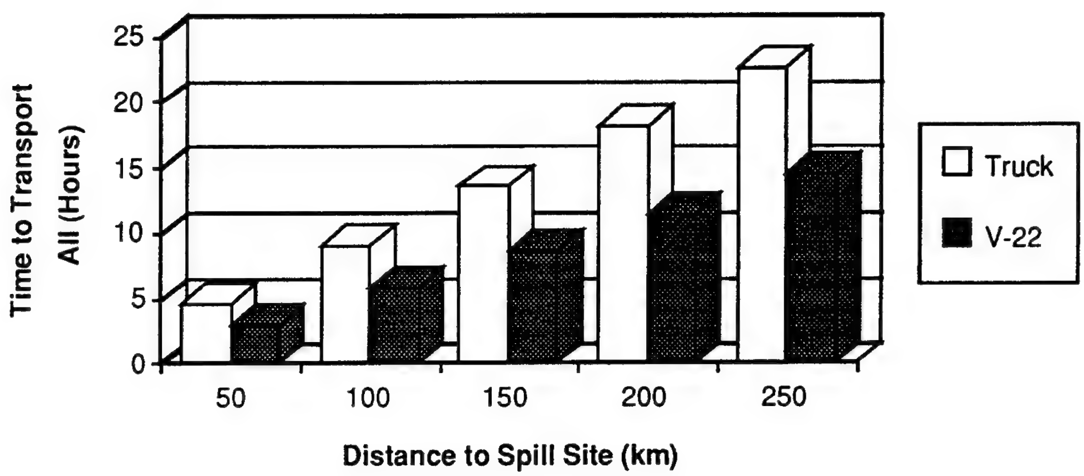


Figure 5-20 - MEP Time to Transport All Equipment to the Spill Site Using One Vehicle

The results presented to this point assumed that the distance traveled to the spill site would be equal for both vehicles. Typically, this is not the case. The routes that the tractor-trailers traverse are usually longer than the course that the V-22 can fly. This is especially true in Alaska where the roads can be through mountainous terrain as seen in Figure 5-21. Assuming that a spill

site is 200 km away and that the tractor-trailer has to travel twice the distance than the V-22 to reach the spill site, the V-22 can reduce the transportation time by 24.6 hours.

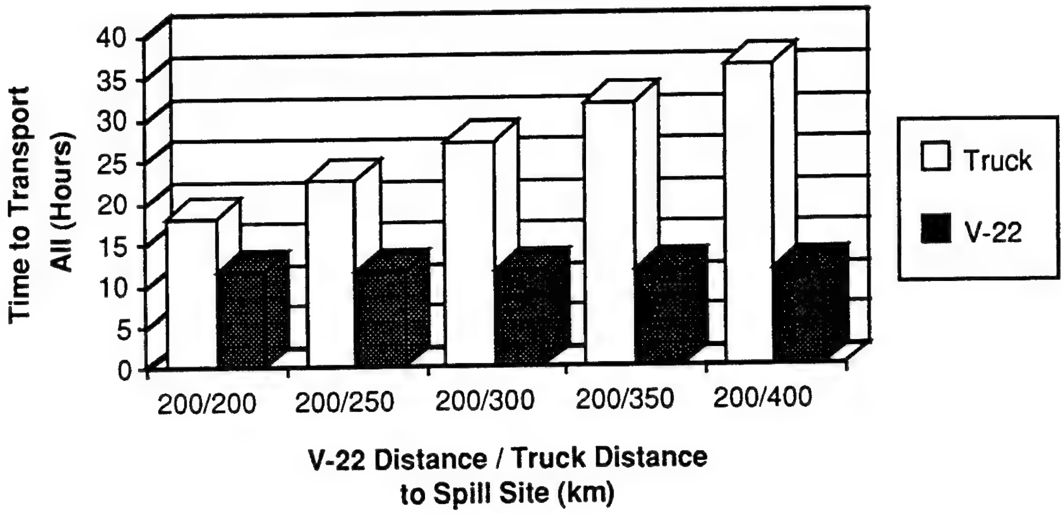


Figure 5-21 - MEP Time to Transport All Equipment to the Spill Site (One Vehicle, Variable Overland Distance)

5.3.4.4 Staging Area Plus Spill Site

One potential advantage offered by the V-22 in transporting the MEP spill containment equipment is the V-22 capability to directly transport the equipment from the strike force location to the spill site. Figure 5-22 is a comparison of the time necessary to transport all of the MEP equipment using one V-22 with the time required for a HC-130H to carry the equipment to the staging area plus two hours for unloading the HC-130H and loading the tractor-trailer and the time required for one tractor-trailer to carry the equipment to the spill site.

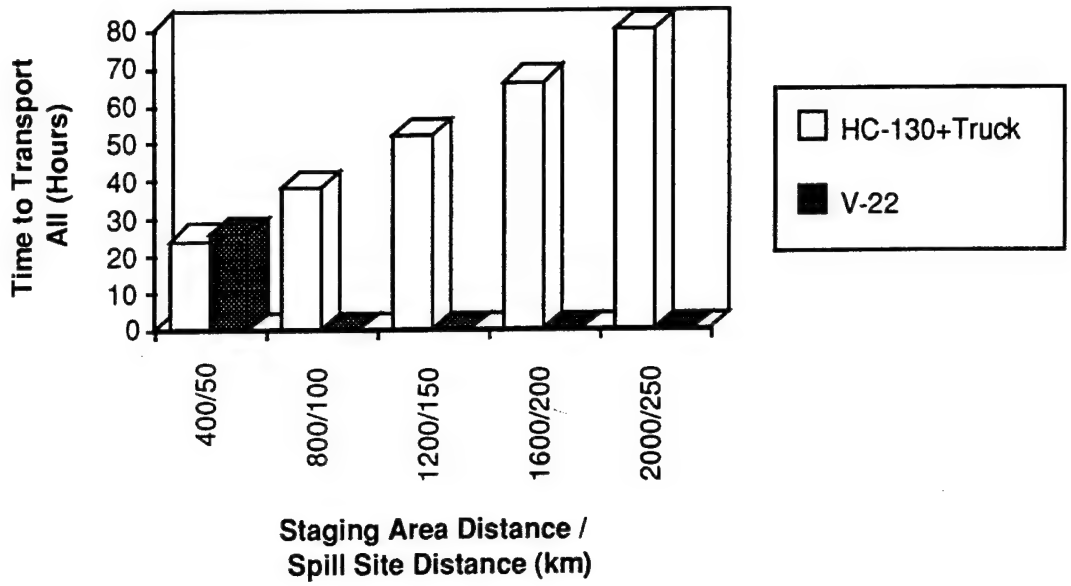


Figure 5-22 - Total Transport Time for All Equipment from Staging Area to Spill Site

In Figure 5-22 the time required to transport the equipment is plotted for several combinations of distances to the staging area and the spill site. For all distance combinations, the HC-130H/tractor-trailer combination out-performs the V-22. For example, when the staging area is 400 km away and the spill site is 50 km from the staging area, the V-22 requires 1.9 hours more to carry the equipment. The factors that drive these results are the greater number of loads the V-22 requires to transport all of the equipment and the distances that the V-22 must travel to reach the spill site.

5.3.4.5 Oil Slick Monitoring

Monitoring the oil slick depends on the ability of the aircraft to cover a large area of water in a single mission. The coverage rate for each aircraft alternative, shown in Figure 5-23, is a measure of the area that an aircraft can monitor in one hour. This measure is a reflection of the velocity that each aircraft monitors the oil slick. The fixed-wing aircraft alternatives can monitor more than twice the area than the helicopters can monitor in a single hour.

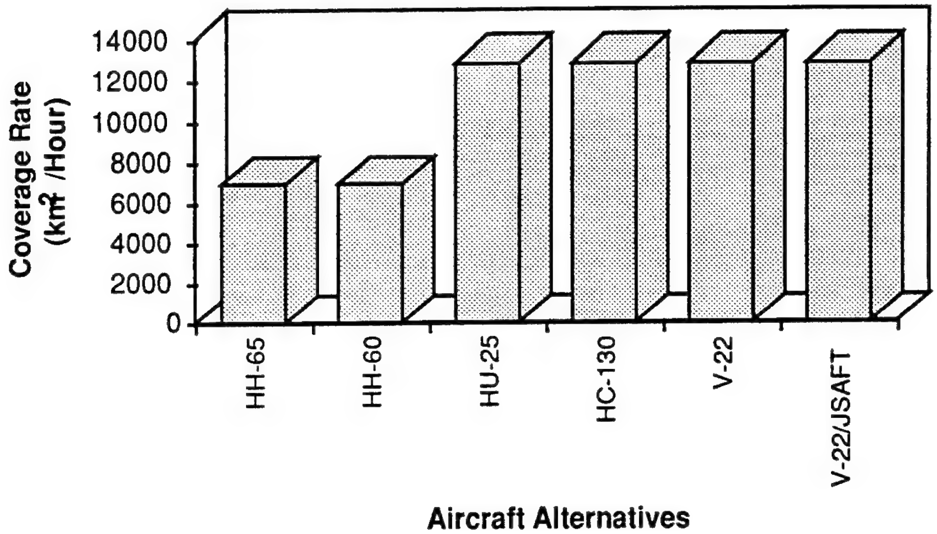


Figure 5-23 - MEP Oil Slick Coverage Rate

The coverage rate does not take into consideration the amount of fuel consumed when traveling to and from the oil spill. Figure 5-24 depicts the area each aircraft alternative can monitor when the distance from the staging area to the spill site varies from 50 to 250 km. At a distance of 50 km, the HC-130H can monitor an area of 187,188 km^2. The V-22 with the JSAFT can monitor the second largest area of 82,458 km^2. The HU-25 and the V-22 can monitor 82,011 km^2 and 65,292 km^2, respectively. Land-based HH-60 and the HH-65 aircraft can monitor an area of 41,082 km^2 and 22,556 km^2, respectively. Deployment of HH-60 and HH-65 aircraft aboard a major cutter would enable monitoring larger spill areas. The relative effectiveness trends remain the same when the distance to the spill site increases to 250 km.

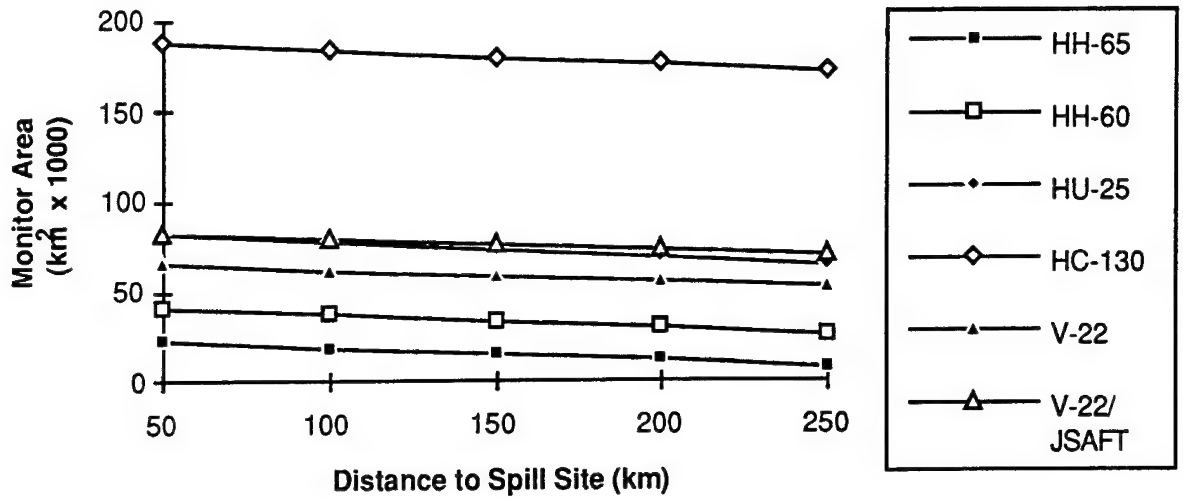


Figure 5-24 - MEP Monitor Area

5.3.4.6 MEP Analysis Summary

The dimensions of the MEP equipment used to contain oil slicks are too great for most of the aircraft alternatives. Only C-130s, tractor-trailers, and V-22s can be used to transport the equipment. The HC-130H is the most effective aircraft for carrying the equipment from the strike force location to the staging area due to its range and the size of the cargo bay. The V-22 is the most effective vehicle for transporting the equipment to the spill site. Several items of equipment, as currently packaged, primarily related to OWOCRS and VOSS, either do not fit the V-22 cabin space or exceed the internal or external load capacity of the V-22. While determination of the feasibility of repackaging these items into V-22 compatible loads is beyond the scope of this study, the margins by which the aircraft dimensions or weights are exceeded suggest that repackaging may be possible.

The operational effectiveness of the aircraft alternatives in monitoring the oil slick is a function of the area that each aircraft alternative can monitor. The V-22 with JSAFT offers substantially greater capability than the baseline aircraft (except the HC-130H) to monitor the oil slick area.

Within the scope of this study, the application of tiltrotor technology, as represented by the V-22, in the Coast Guard Marine Environmental Program would contribute to minimizing of the damage caused by oil or other hazardous substances spills in the waters of the United States.

Section 6.0
Manpower and Operating Cost Analysis

6.1 Overview

This section concentrates on two types of cost measures, i.e., the costs associated with operating the aircraft alternatives and the costs associated with manning the aircraft alternatives. These costs are discussed in detail in Section 6.2 and Section 6.3, respectively. Additionally, the raw data gathered for this analysis can be found in Appendix B.4.

6.2 Cost Analysis Methodology

The objective of the cost research and analysis effort was to provide insight on the V-22 aircraft operational and manpower cost for a Coast Guard operation. A review was conducted on available Coast Guard data for the current fleet of aircraft and on the related studies of the V-22 for DoD service utilization. A clear comparison of the aircraft costs was precluded by differences in the accounting systems and reporting requirements of the Coast Guard and the Navy. These two accounting systems did not capture the same elements of data and did not display direct and indirect costs in the same manner. Additionally, the substantial differences in aircraft employment concepts between the Coast Guard and the Navy and Marine Corps contributed to the difficulty of projecting an Operating and Support (O&S) cost for the V-22 within the Coast Guard. Therefore, the use of a service, i.e., Navy, operating and support cost model was not appropriate since the data for Coast Guard aircraft had not been accumulated in a manner that was meaningful with respect to the Navy O&S model and the presentation of such data would not have any meaning within the Coast Guard context. The approach taken assumes that, regardless of accounting systems, the real cost of operating and supporting an aircraft model is the same when the operating conditions are the same such that, for example, a Navy H-60 equipped, supported, and flown in the same manner as a Coast Guard HH-60J would have the same O&S cost as the HH-60J. This approach further assumes that if a cost relationship exists between two aircraft operated within one operational employment concept, then a similar relationship would exist between the two aircraft when operated in a different employment concept.

6.2.1 Examination of Data

A data search was accomplished to make a cost analogy from a service position to the Coast Guard. Consistency in data forces decisions to be made on what data will be used in the final

analysis. For instance, the Center of Naval Analysis Cost and Operational Effectiveness Analysis was not used primarily due to age. These data were generated nearly two years before the data developed for the Institute for Defense Analysis (IDA) study which was completed in 1990. The Air Force did not develop operating and support projections for the Air Force variant. Their efforts addressed the deltas in Research and Development costs as well as Production changes for additional equipment (primarily avionics) which would be required for Air Force missions. Operating and support data which were provided by the Coast Guard centered around projections for material and fuel usage.

Naval Air Systems Command (PMA 275) provided data for the MV-22 and two H-60 configurations being studied in 1990, i.e., CH-60 and the CH-60 (S) . These data were prepared in February 1990 using FY 88 dollars as the base year. The CH-60 and CH-60 (S) were hypothetical aircraft based on the Army UH-60 but configured for the Marine Corps assault support mission. The CH-60 (S) was a "stretched" variant of the CH-60. The CH-60 and CH-60 (S) did not have the extensive avoinics suite incorporated in the HH-60J. However, the Marine MV-22 does not have the systems capabilities required by the HH-60J. Therefore, the relationship for the estimated O&S costs for the CH-60 and CH-60 (S) and the MV-22 is assumed to be the same as the relationship between the O&S costs of the HH-60J and those projected for Coast Guard employment of the V-22. The Navy utilization of the aircraft was based on a 35 hour per month (420 yearly) flying hour program and a 12 aircraft per squadron basing pattern. Based on the G-OAV Aircraft Utilization FY92 (Oct 91 - Sep 92), the Coast Guard would operate in a 700 - 800 yearly flying hour program and a basing structure of 3 to 9 aircraft at an air station. With the different modes of basing and utilization, these data were used strictly on an average cost per flying hour basis versus annual aircraft cost or average cost of a squadron. The normalization of the data to base year FY1993 dollars was accomplished using DoD raw inflation indices published in March 1993. After examining the data for consistency, it was determined the fuel was being overstated by the current indices. The Navy had originally used $0.17 per liter as fuel cost. Inflating the $0.17 to base year 93, using the fuel indices would have resulted in a $0.36 per liter cost for fuel. The Coast Guard used $0.26 in FY 92 for fuel and an inflation growth of 3 percent to FY 93. For consistency purposes fuel was adjusted to the $0.27 cost per liter of fuel. Table 6-1 displays the basic data as provided by the Navy.

Table 6-1 - NAVAIR Operating and Support Data (FY 88, Dollars in Thousands)

	MV-22		CH-60(S)		CH-60	
UNIT MISSION SQDN MANNING	OFFICER	ENLISTED	OFFICER	ENLISTED	OFFICER	ENLISTED
1. AIRCREW	28	19	28	19	28	19
2. MAIN PERSON	3	171	3	195	3	195
3. OTHER UNIT PERSONNEL	2	17	2	25	2	25
TOTAL PERSONNEL	33	207	33	239	33	239
OPER A/C PER SQDN	12		12		12	
FH/YR	420		420		420	
OPERATING & SUPPORT COSTS						
UNIT MISSION PERSONNEL						
1. AIRCREW	$290		$294		$294	
2. MAINT PERSON	$450		$503		$503	
3. OTHER UNIT PERSON	$55		$75		$75	
SUB-TOTAL	$795		$872		$872	
UNIT LEVEL CONSUMPTION						
4. POL	$83		$44		$43	
5. MAIN MATERIAL	$277		$167		$166	
6. PERSONNEL SUPPORT SUPPLIES	$18		$8		$8	
7. TRAINING ORDNANCE	$25		$25		$25	
SUB-TOTAL	$403		$244		$242	
DEPOT LEVEL MAINTENANCE						
8. AIRFRAME REWORK	$133		$89		$78	
9. ENGINE REWORK	$19		$6		$6	
10. COMPONENT REWORK	$254		$127		$123	
11. OTHER DEPOT SUPPORT	$32		$24		$22	
12. INSTALLATION MODS	$8		$3		$3	
SUB-TOTAL	$446		$249		$232	
SUSTAINING INVESTMENT						
13. REPLENISHMENT SPARES	$243		$82		$79	
14. REPLACE SE	$94		$23		$21	
15. MOD PROCUREMENT	$82		$29		$28	
SUB-TOTAL	$419		$134		$128	
INSTALLATION SUPPORT						
16. BOS PERSON	$10		$12		$12	
17. HEALTH CARE SUPT PERSONNEL	$6		$6		$6	
SUB-TOTAL	$16		$18		$18	
INDIRECT PERSON SUPPORT						
18. BASE OPERATING SPT	$10		$11		$11	
19. HEALTH CARE SPT	$5		$5		$5	
20. PERMANENT CHG OF STATION						
21. TEMP ADDL DUTY						
SUB-TOTAL	$15		$16		$16	
DEPOT NON MAINTENANCE						
22. GEN DEPOT SUPPLY	$49		$25		$24	
23. 2ND DEST TRANSP	$38		$19		$19	
24. OTHER SUPPORT	$97		$47		$44	
SUB-TOTAL	$184		$91		$87	
TOTAL O & S COST/AC/YEAR FY88 $ in K	$2278		$1624		$1595	
TOTAL DIRECT/AC/YEAR FY 88 $ in K	$2063		$1499		$1474	
AVER FLY HOUR FY 88 $ in K	$5.424		$3.867		$3.798	
DIR AVERAGE FLYING HOUR FY 88 $ in K	$4.912		$3.569		$3.510	

Table 6-2 is a recap of these data inflated to base year 93 shown at the annual aircraft and the flying hour level after the adjustment for fuel cost. Dollars are shown in thousands.

Table 6-2 - Recap Of NAVAIR Operating and Support Data
Inflated To FY93, Dollars In Thousands

	MV-22	CH-60(S)	CH-60
ANNUAL AIRCRAFT COST			
MANPOWER	$960	$1,053	$1,053
FUEL	$130	$69	$67
MATERIAL	$1,411	$694	$665
OTHER	$270	$165	$160
TOTAL FY93 $ in K	$2,771	$1,981	$1,945
AVERAGE FLYING HOUR COST			
MANPOWER	$2.286	$2.507	$2.507
FUEL	$0.309	$0.164	$0.160
MATERIAL	$3.359	$1.652	$1.584
OTHER	$0.643	$0.392	$0.381
TOTAL FY 93 $ in K	$6.597	$4.715	$4.632

There are a few basic observations on the cost results of the Navy's utilization which can be derived after examining these data:

1. Manpower is projected to be less on the V-22 than the CH-60 even with the crew size being the same. There is a 14.2% reduction in non crew personnel between the H-60 and the V-22, i.e., 193 V-22 non-crew compared to 225 H-60 non-crew.

2. The V-22 uses approximately 90% more fuel than the H-60. Composite fuel rate for the V-22 was 1136 liter per hour while the average fuel rate for the H-60 was 594 liter per hour.

3. Material usage on the V-22 is approximately a 107% increase from the average of the H-60. Table 6-3 is a detail display of the material lines of the Navy data. This comparison must be accomplished with the realization that the difference in average unit flyaway cost and the weight of the V-22 air vehicle is more than double that of the H-60.

Table 6-3 - NAVAIR Data FY93 Material Elements

FY 93 $ IN THOUSANDS	MV-22 $/FLIGHT HR	CH-60(S) $/FLIGHT HR	CH-60 $/FLIGHT HR	DELTA FROM MV-22 TO AVERAGE CH-60	% OF CHANGE
UNIT LEVEL CONSUMPTION					
MAIN MATERIAL	$0.785	$0.473	$0.470	$0.313	166%
PERSONNEL SUPPORT SUPPLIES	$0.051	$0.023	$0.023	$0.028	225%
TRAINING ORDNANCE	$0.071	$0.071	$0.071	$0.000	100%
SUB-TOTAL	$0.907	$0.567	$0.564	$0.341	160%
DEPOT LEVEL MAINTENANCE					
AIRFRAME REWORK	$0.377	$0.252	$0.221	$0.140	159%
ENGINE REWORK	$0.054	$0.017	$0.017	$0.037	317%
COMPONENT REWORK	$0.720	$0.360	$0.349	$0.366	203%
OTHER DEPOT SUPPORT	$0.091	$0.068	$0.062	$0.026	139%
INSTALLATION MODS	$0.023	$0.009	$0.009	$0.014	267%
SUB-TOTAL	$1.265	$0.706	$0.658	$0.583	185%
SUSTAINING INVESTMENT					
REPLENISHMENT SPARES	$0.689	$0.232	$0.223	$0.461	302%
REPLACE SE	$0.266	$0.065	$0.060	$0.204	427%
MOD PROCUREMENT	$0.232	$0.082	$0.079	$0.152	288%
SUB-TOTAL	$1.187	$0.379	$0.362	$0.817	320%
TOTAL MATERIAL	$3.359	$1.652	$1.584	$1.741	207%

This table shows the values of each aircraft type, the delta increase for each line for the MV-22 from the average of the H-60, and the percentage increase for the V-22 over the average of the H-60. A review of the individual elements which are the drivers of this increase were examined. The cost estimating relationships (CER) used to develop these aircraft estimates were developed by the Naval Center for Cost Analysis from a Navy historical data base. The MV-22 was estimated using CERs developed for fixed wing aircraft while the H-60 CER were helicopter based.

1. Unit Level Consumption -- Maintenance Material delta per flying hour was $313 which was 66% over the H-60 average. These CERs were based on the airframe unit weight (AUW) and maximum speed for the H-60 and aircraft empty weight for the V-22.

2. Depot Level Maintenance -- Airframe and Component Rework were the largest drivers accounting for $570 increase. These CER were based on the AUW, maximum range and the Depot Maintenance interval.

3. Sustaining Investment -- Replenishment spares accounted for $461 increase and was based on airframe unit weight. Replacement support equipment accounted for $204 increase and was based on the cumulative average unit flyaway of the first 100 production aircraft.

These input factors were all significant between the aircraft. For example, AUW for the H-60 was 4,990 kg while the MV-22 was 13,154 kg. Outputs from the CER will not be purely proportional to the input due to the differences in constants and exponents of the two sets of equations.

6.2.2 Measures of Cost

The examination of the Coast Guard Hourly Standard Rate For Aircraft is the best basis for an overall comparison. The reported hourly standard rate for outside government per aircraft for FY 92 was displayed in Enclosure (2) to COMDTINST 7310.1E as shown in Table 6-4

Table 6-4- Outside the Government Hourly Standard for Aircraft, FY92

Class/Type	Facility Cost	Field Operational Support	Administrative Support	Depreciation	Total FY92$
HC-130	$2,102	$1,001	$931	$210	$4,244
HH-65	$1,887	$795	$805	$280	$3,767
HU-25	$2,185	$490	$803	$410	$3,888
HH-60J	$2,204	$1,048	$976	$979	$5,207

Since the Navy data are presented in FY93, the Coast Guard data were also normalized by using a consistent 3% factor from FY92 to FY93. This information is shown in Table 6-5.

Table 6-5 - Outside the Government Hourly Standard Rate for Aircraft, Inflated for FY93

Class/Type	Facility Cost	Field Operational Support	Administrative Support	Depreciation	Total FY93$
HC-130	$2,165	$1,031	$959	$216	$4,371
HH-65	$1,944	$819	$829	$288	$3,880
HU-25	$2,251	$505	$827	$422	$4,005
HH-60J	$2,204	$1,079	$1,005	$1,008	$5,296

The Coast Guard developed the Standard Rate for the HH-60J using the operating costs and depreciation differences relative to the H-3. This technique, which was used in the Encl (2), COMDTINST 7310.1, was also used for this analysis. Deltas were established for fuel, unit maintenance, and depot maintenance in the Facility Cost area. Field Operational Support and Administrative will remain constant to the HH-60J and a delta will be established for depreciation.

6.2.3 Projection of Coast Guard Operating Cost

The HH-60J data, provided by the Coast Guard as backup to the Aircraft Operations Cost, was used as a baseline for comparison to the Navy. These data, though originally in FY92 dollars, have been updated to FY93 using a 3% inflation factor.

The HH-60J data inflated to FY93 dollars:

Fuel, 541 liters per hour @ $0.27 per liter	$ 147
Unit Maint per flying hour	$ 207
Depot Maint cost per flying hour	$1,124
Material use per flying hour, FY 93$	$1,478

Projecting the cost of material used for a V-22 aircraft used by the Coast Guard requires utilizing a baseline for the Coast Guard which accounts for the flight profiles, maintenance, and readiness practices of the Coast Guard. The best comparable data are with the Coast Guard HH-60 and the Navy projections for the CH-60 configurations. Initially the Navy use of the CH-60 was compared to the MV-22 to determine the difference in the Navy utilization of these aircraft types.

A ratio of these differences between aircraft types was then applied to the baseline HH-60J within the Coast Guard to project the Coast Guard use of a V-22. The following data, Table 6-6, are the Navy data presented on a flying hour basis showing the relationship of the operating costs within the Navy for the CH-60 configurations and the MV-22.

Table 6-6 - NAVAIR CH-60(S) and CH-60 Data Compared to MV-22 Average Flying Hour Costs
FY93 Dollars

	CH-60(S)	CH-60	AVERAGE CH-60 & CH-60(S)	MV-22	CHANGE
FUEL	$164	$160	$162	$310	191%
MATERIAL	$1,652	$1,583	$1,618	$3,360	207%
TOTAL	$1,817	$1,743	$1,780	$3,669	

6.2.3.1 Fuel

The Navy displayed two series of the H-60 in their data. The fuel used was relatively consistent with one at $164 per flying hour and the other at $160. Using the average of these two for a smoothing effect, the comparative number would be $162. The MV-22 usage was $310 or 191% of the fuel cost for a CH-60. Applying this percentage increase to a Coast Guard HH-60 baseline hourly fuel usage, the Coast Guard usage of the V-22 should be $281.

6.2.3.2 Material

The material used was consistent with one Navy H-60 series at $1,652 and the other at $1,584. Again, using the average of the two, the comparative number would be $1,618. The MV-22 usage was $3,360 or 207% of the material cost for the CH-60. Applying the same percentage increase to a Coast Guard HH-60 baseline hourly material usage, the Coast Guard usage should be $2,755

	PERCENTAGE	HH-60	V-22
Fuel	191%	$ 147	$ 281
Material	207%	$1,331	$2,755
Total FY 93$		$1,478	$3,036

6.2.4 Projection of Coast Guard Hourly Standard Rate for the V-22

Using the HH-60J as a baseline cost for the Hourly Standard Rate of the Aircraft, the V-22 can be approximated by establishing deltas with respect to the HH-60J position. Since the Coast Guard HH-60 annual program hours (800) are the same as those projected for Coast Guard V-22 utilization and that relationship is identical to the Navy relationship of 420 flight hours annual Navy usage for both H-60 and V-22, the projected Coast Guard V-22 costs do consider the greater V-22 usage rate predicted for the Coast Guard.

6.2.4.1 Facility Cost

From Table 6-5, the facility cost for the HH-60J is $2,204/flight hour. The delta to be added to the HH-60J facility cost is $1,558/flight hour, which is determined by subtracting the HH-60 operating costs ($1,478) from the projected V-22 operating costs ($3,036). The Facility Cost for the V-22 is $3,762.

6.2.4.2 Field Operational and Administrative Support

Field Operational Support and Administrative Support are held constant in this analysis to the HH-60J. The Navy data on the CH-60 and the MV-22 show a reduction in the staffing dollars and an increase in the material items in the Navy Operation. The effects of reduced staffing and the increased material should have a negating effect within this total area. Examination of the data for staffing and material used did not reveal a consistent correlation for the Operating Costs to the Field Operational and Administrative Support Area.

6.2.4.3 Depreciation

Depreciation is based on three basic inputs consisting of service life, annual flying hours, and flyaway costs. The service life was assumed to be 20 years and yearly flying hour program to be 800 hours. The average unit flyaway cost of the aircraft was determined by using the Air Force production estimate which was prepared in March 1989. The aircraft numbers are currently being re-estimated by NAVAIRSYSCOM and will change from this position. The Air Force production numbers were used since the more extensive avionics suite included in the Air Force variant more closely resembles potential Coast Guard requirements. Extending this number to FY 93 yields a

base year average unit flyaway of $31.3 M. The computation for an hourly depreciation would be $1,956.

Table 6-7 displays the government hourly standard rate to be used in this analysis.

Table 6-7- Outside the Government Hourly Standard Rate for Aircraft FY 93 Dollars

Class / Type	Facility Cost	Field Operational Support	Administrative Support	Depreciation	Total
V-22	$3,762	$1,079	$1,005	$1,956	$7,802
HH-60	$2,204	$1,079	$1,005	$1,008	$5,296
HC-130	$2,165	$1,031	$959	$216	$4,371
HU-25	$2,251	$505	$827	$422	$4,005
HH-65	$1,944	$819	$829	$288	$3,880

6.2.5 Operating Cost Summary

The Aircraft Operating Cost comparison with the V-22 in the Coast Guard fleet is shown in Table 6-8. The Aircraft Operating Cost is defined as the cost of fuel and material. These costs are displayed as a percentage of the V-22 cost or in equivalent hours. The equivalent hours is presenting the number or hours an alternative aircraft can be flown in comparison to one hour of the V-22.

Table 6-8 - Aircraft Operating Cost and Operating Hours

	USCG Operating Costs (FY93 $K)	USCG Costs Expressed as a Percent of V-22	Equivalent Operating Hours
V-22	$3.0	100%	1.0
HC-130	$2.0	67%	1.5
HU-25	$1.7	57%	1.8
HH-60J	$1.5	50%	2.0
HH-65A	$1.3	43%	2.3

The Outside Government Hourly Standard Rate For Aircraft comparison with the V-22 in the Coast Guard fleet is shown in Table 6-9. These rates are displayed as a percentage of the V-22 rate or in equivalent hours. These numbers of equivalent hours represent the number of hours an alternative aircraft can be flown in comparison to one hour of the V-22.

Table 6-9 - Aircraft Hourly Standard Rate

	USCG Standard Hourly Rate (FY93 $K)	USCG Rates Expressed as a Percent of V-22	Equivalent Operating Hours
V-22	$7.8	100%	1.0
HC-130	$4.4	56%	1.8
HU-25	$4.0	51%	2.0
HH-60J	$5.3	68%	1.5
HH-65A	$3.9	50%	2.0

The results depicted in Tables 6-8 and 6-9 are nearly equal. This consistency of data allows reasonable use of either measure in an effectiveness analysis.

6.3 Manpower Analysis

6.3.1 Manpower Analysis Methodology

The manpower analysis for the Coast Guard use of a V-22 is based on the current staffing information for the Coast Guard baseline aircraft alternatives and the Navy projections for the use of the MV-22 within the Navy. The basing data for Coast Guard aircraft in the FY 92 Utilization report was used as a baseline position for staffing. A review of the data reveals the basing structure per aircraft type as shown in Table 6-10. Note that since several CGAS have more than one aircraft type, the number of bases shown is greater than the actual number of CGAS, i.e., 27.

Table 6-10 - FY 92 Basing Structure per Aircraft Type

AIRCRAFT	NUMBER OF BASES WITH			
PER STATION	HH-60J	HC-130	HU-25	HH-65A
2			1	1
3	5	2	2	8
4	2	2		4
5				3
6		2	1	1
8			1	1
9				1
10			1	
12	1			
TOTAL BASES	8	6	6	19
TOTAL FLEET SIZE	35	26	32	80

This information was combined with the Coast Guard generic staffing pattern to calculate a weighted average for staffing of each aircraft type. The technique which was used developed a total / average staffing for each aircraft type. Appendix B.4 displays the generic staffing pattern provided by the Coast Guard, multiplied by the number of bases with that pattern, and summed to a total fleet size. Table 6-11 show the results of that summation and the averaging by the fleet size.

Table 6-11 - Fleet Size Average Staffing per Aircraft

	HH-60J FLEET SIZE 35		HC-130H FLEET SIZE 26		HU-25 FLEET SIZE 32		HH-65A FLEET SIZE 80	
	OFF	ENL	OFF	ENL	OFF	ENL	OFF	ENL
CREW	2.00	2.00	2.00	5.00	2.00	3.00	2.00	1.00
OTHER	2.34	14.63	2.08	17.00	1.69	8.19	2.00	10.00
BOS	0.74	1.17	0.69	2.77	0.63	1.47	0.74	0.89
TOTAL	5.09	17.80	4.77	24.77	4.32	12.66	4.74	11.89

The average staffing for the Navy position was provided by NAVAIRSYSCOM (PMA-275) for a 1990 analysis. The Navy staffing for the CH-60 and the MV-22 was based on a 12 aircraft squadron. The comparison from the CH-60 to the V-22 was accomplished at the three basic levels (Crew, Other Direct to Aircraft, and Base Operating and Support (BOS)) for Officer and Enlisted. Percentages were developed for the amount of staffing used on the MV-22 when compared to the usage on the CH-60. The Navy has projected the same staffing, as seen in Table 6-12, in all categories for Officers and the Enlisted Crew, while projecting reductions in the Enlisted Other Direct to Aircraft and BOS.

Table 6-12 - Navy Twelve-Aircraft Squadron Staffing

	CH-60		V-22		COMPARISON	
	OFFICER	ENLISTED	OFFICER	ENLISTED	OFFICER	ENLISTED
CREW	28	19	28	19	100%	100%
OTHER DIRECT	3	195	3	171	100%	88%
BOS	2	25	2	17	100%	68%
TOTAL	33	239	33	207	100%	87%

These percentages were then applied to the Coast Guard HH-60J average staffing to provide an analogous staffing level for the Coast Guard V-22. For example, the ratio of 68%, i.e., for the V-22 compared to the CH-60 Enlisted BOS, applied to the Coast Guard average enlisted BOS of 1.17 yields a projected enlisted BOS for the V-22 of 0.80. Table 6-13 shows the results of this computation.

Table 6-13 - Analogous Coast Guard V-22 Staffing Levels

COAST GUARD AVERAGE PER AIRCRAFT FLEET OF 35					
	HH-60J			V-22	
	OFFICER	ENLISTED		OFFICER	ENLISTED
CREW	2.00	2.00	CREW	2.00	2.00
OTHER DIRECT	2.34	14.63	OTHER DIRECT	2.34	12.83
BOS	0.74	1.17	BOS	0.74	0.80
TOTAL	5.09	17.80	TOTAL	5.09	15.62

The average staffing of the V-22 at 5.09 Officers and 15.62 Enlisted was compared to the average staffing of the HH-60, HC-130, HU-25, and HH-65A and deltas were established with negative numbers being reductions from basic staffing of a V-22 and the positive numbers an increase. The results are shown at the basic three levels within Officers and Enlisted in Table 6-14.

Table 6-14 - V-22 per Aircraft Manpower Deltas

	HH-60J		HC-130		HU-25A		HH-65A	
	OFF	ENL	OFF	ENL	OFF	ENL	OFF	ENL
CREW	0.00	0.00	0.00	3.00	0.00	1.00	0.00	-1.00
OTHER DIRECT	0.00	1.80	-0.26	4.17	-0.65	-4.64	-0.34	-2.82
BOS	0.00	0.37	-0.05	1.97	-0.11	0.67	0.00	0.09
TOTAL	0.00	2.17	-0.31	9.14	-0.76	-2.97	-0.34	-3.73

The comparison of equivalent staffing can best be accomplished in dollar terms. U. S. Coast Guard Standard Personnel Cost (SPC) Tables, 20 April 93, were used to develop the personnel cost. This cost is illustrated in Table 6-15.

Table 6-15 - V-22 per Aircraft Manpower Costs

	V-22		HH-60		HC-130		HU-25		HH-65A	
	OFF	ENL	OFF	ENL	OFF	ENL	OFF	ENL	OFF	ENL
CREW	2.00	2.0	2.00	2.00	2.00	5.00	2.00	3.00	2.00	1.00
OTHER	2.34	12.83	2.34	14.63	2.08	17.00	1.69	8.19	2.00	10.00
BOS	0.74	0.80	0.74	1.17	0.69	2.77	0.63	1.47	0.74	0.89
TOTAL	5.09	15.62	5.09	17.80	4.77	24.77	4.31	12.66	4.74	11.89
FY 93$ IN K	$282	$415	$282	$472	$264	$657	$239	$336	$263	$315
AIRCRAFT TOTAL (FY93 $K)		$696		$754		$921		$575		$578
1993 Annual Standard Personnel Salary Costs When Rank Is Not Known OFFICERS $55,424 ENLISTED $26,530										

6.3.2 Manpower Analysis Results

The average manpower cost for the V-22 is $696 and is used as a baseline for comparison to the other four aircraft. The HH-60 is a 8% increase over the V-22 manpower cost, the HC-130 is a 32% increase, the HU-25 and the HH-65A are a 17% reduction. The data in Table 6-16 are recapitulation of this analysis.

Table 6-16 - Equivalent Personnel Costs using V-22 as the Base

AIRCRAFT	PERCENT OF V-22 PERSONNEL COSTS
V-22	100%
HH-60J	108%
HC-130	132%
HU-25	83%
HH-65A	83%

To make the comparison from purely a staffing relationship, 37 V-22 aircraft can be operated at the same staffing cost presently required for the HH-60 fleet of 35. These relationships with the other aircraft are shown in Table 6-17.

Table 6-17 - Equivalent Fleet Sizes

	Current Fleet Size	V-22 Fleet Size*
HH-60J	35	37
HC-130	26	34
HU-25	32	26
HH-65A	80	66
* Fractional aircraft were dropped		

Section 7.0
Cost and Operational Effectiveness

Sections 5.0 and 6.0 outline the operational effectiveness and the manpower and operating cost of each alternative aircraft in the Coast Guard mission components of Search and Rescue, Law Enforcement/Maritime Interdiction, and Marine Environmental Protection. The purpose of this section is to integrate these measures to develop the costs associated with each mission component. Section 7.1 shows the cost effectiveness comparisons for SAR, Section 7.2 illustrates the LE/MI results, and Section 7.3 displays the MEP results. The Outside Government Hourly Standard Rate (GHSR-O) costs, as calculated in Section 6.0, are used in this section to calculate the cost effectiveness of each aircraft alternative. The FY 93 GHSR-O for each aircraft alternative are: HH-65 - $3,880; HH-60 - $5,296; V-22/V-22 w/JSAFT - $7,802; HU-25 - $4,005; and HC-130 - $4,371.

7.1 SAR Cost and Operational Effectiveness Results

The operational effectiveness of USCG assets in SAR missions is ultimately measured by its ability to save personnel and property in distress. While differences in performing the various elements of the SAR mission component were discussed in Section 5.1, this section will attempt to provide some insight on the most cost effective alternatives for executing various SAR missions. For purposes of this analysis, two broad mission categories are examined; those in which victim extraction is paramount and those in which victim location and assistance is paramount. This analysis examines equal mission effectiveness cases in each of the broad mission categories to assess the cost implications of using one alternative or another. In the extraction mission, mission ranges of 148 and 371 km are examined and in the victim location mission, ranges of 148, 371, and 741 km are used to compare alternatives.

7.1.1 Victim Extraction

For those missions in which victim extraction is paramount, there are eight alternatives for consideration: HH-65, HH-60, HU-25+HH-65, HU-25+HH-60, HC-130+HH-65, HC-130+HH-60, V-22, and V-22 w/JSAFT. The V-22 alternatives can search in both a fixed-wing mode and a rotary-wing mode and each of these configurations are compared in this analysis. In the cases involving mixes of fixed-wing and rotary-wing aircraft, the fixed-wing aircraft launches first to conduct the search. After locating the victims, they notify the CGAS to launch the rotary-wing aircraft to effect the extraction at the rescue site. The fixed-wing aircraft remains on

station (wait time) until the helicopter arrives. All alternatives will be compared within the context of a SAR mission involving mission phases of initial response time, enroute time, location time, extraction time, and return to base time. Two cases will be examined involving the extraction of three persons at distances of 148 and 371 km from the launch point. The data for the 148 km mission are presented in Tables 7-1 (single aircraft) and 7-2 (fixed-wing/rotary-wing mixes).

Table 7-1 - Victim Extraction Mission - 148 km

	HH-65		HH-60		V-22/V-22 w/JSAFT [1]		V-22/V-22 w/JSAFT [2]	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARM UP	0.25	970	0.25	1324	0.25	1950	0.25	1950
ENROUTE	0.6	2328	0.6	3178	0.3	2340	0.3	2340
LOCATION (37 KM SEARCH)	0.2	776	0.2	1059	0.1	780	0.2	1560
EXTRACTION (3 VICTIMS)	0.25	970	0.25	1324	0.25	1950	0.25	1950
RTB	0.6	2328	0.6	3178	0.3	2340	0.3	2340
TOTALS	1.9	7372	1.9	10064	1.2	9361	1.3	10141

1 Fixed-wing mode during search

2 Rotary-wing mode during search

Table 7-2 - Victim Extraction Mission - 148 km (Aircraft Mixes)

	HU-25 + HH-65		HU-25 + HH-60		HC-130 + HH-65		HC-130 + HH-60	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARM UP	0.25	1001	0.25	1001	0.25	1093	0.25	1093
ENROUTE	0.2	801	0.2	801	0.3	1311	0.3	1311
LOCATION (37 KM SEARCH)	0.1	401	0.1	401	0.1	437	0.1	437
WAIT TIME [1]	1.1	4406	1.1	4406	1.1	4808	1.1	4808
EXTRACTION (3 VICTIMS)	0.25	970	0.25	1324	0.25	970	0.25	1324
RTB (FW)	0.2	801	0.2	801	0.3	1311	0.3	1311
RTB (HELO)	0.6	2328	0.6	3178	0.6	2328	0.6	3178
TOTALS	2.7	10707	2.7	11912	2.9	12259	2.9	13463

1 WAIT TIME is the time the fixed-wing aircraft must remain over the target until the helicopter arrives on station.

As indicated, the HH-65 is the most cost effective alternative for the short range (148 km) SAR mission involving three or less extractions. The V-22 (fixed-wing search mode), which is second, would have to reduce its GHSR-O by $1658 to approach the HH-65. The HH-60 is third

and costs approximately $370 per hour more than the V-22 to complete the mission. The mixing of aircraft to effect the extraction mission is significantly less cost effective than all other alternatives.

For the longer 371 km mission, the HH-65 is not a viable alternative, so only the HH-60, HU-25+HH-60, HC-130+HH-60, and V-22 alternatives are compared. The data for this mission are depicted in Tables 7-3 and 7-4.

Table 7-3 - Victim Extraction Mission - 371 km

	HH-60		V-22/V-22 w/JSAFT [1]		V-22/V-22 w/JSAFT [2]	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARM UP	0.25	1324	0.25	1950	0.25	1950
ENROUTE	1.4	7416	0.8	6241	0.8	6241
LOCATION (37 KM SEARCH)	0.2	1059	0.1	780	0.2	1560
EXTRACTION (3 VICTIMS)	0.25	1324	0.25	1950	0.25	1950
RTB	1.4	7416	0.8	6241	0.8	6241
TOTALS	3.5	18540	2.2	17162	2.3	17942

1 Fixed-wing mode during search

2 Rotary-wing mode during search

Table 7-4 - Victim Extraction Mission - 371 km (Aircraft Combinations)

	HU-25 + HH-60		HC-130 + HH-60	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARM UP	0.25	1001	0.25	1093
ENROUTE	0.5	2003	0.7	3060
LOCATION (37 KM SEARCH)	0.1	401	0.1	437
WAIT TIME [1]	1.9	7610	1.9	8305
EXTRACTION (3 VICTIMS)	0.25	1324	0.25	1324
RTB (FW)	0.5	2003	0.7	3060
RTB (HELO)	1.4	7416	1.4	7416
TOTALS	4.9	21756	5.3	24694

1 WAIT TIME is the time the fixed-wing aircraft must remain over the target until the helicopter arrives on station.

The V-22 alternatives are nearly equal and are the most cost effective. The HH-60 is third and would have to reduce its GHSR-O by approximately $390 to approach the V-22 cost effectiveness. As was the case previously, the aircraft mixes are significantly less cost effective than the other alternatives.

7.1.2 Search/Assistance

For the mission in which victim extraction is not a consideration, three cases are examined: 148 km, 371 km, and 741 km. Only single aircraft alternatives are considered. The data for these cases are presented in Tables 7-5 through 7-9. For the 741 km mission, the HH-65, HH-60, and V-22 are not viable alternatives so only the HU-25, HC-130, and V-22 w/JSAFT alternatives are compared.

Table 7-5 - Victim Search/Assistance Mission - 148 km (Rotary -Wing)

	HH-65		HH-60		V-22/V-22 w/JSAFT	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARM UP	0.25	970	0.25	1324	0.25	1950
ENROUTE	0.6	2328	0.6	3178	0.3	2340
LOCATION (37 KM SEARCH)	0.2	776	0.2	1059	0.2	1560
RTB	0.6	2328	0.6	3178	0.3	2340
TOTALS	1.65	6402	1.65	8740	1.05	8191

Table 7-6 - Victim Search/Assistance Mission - 148 km (Fixed-Wing)

	HU-25		HC-130		V-22/V-22 w/JSAFT	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARMUP	0.25	1001	0.25	1093	0.25	1950
ENROUTE	0.2	801	0.3	1311	0.3	2340
LOCATION (37 KM SEARCH)	0.1	401	0.1	437	0.1	780
RTB	0.2	801	0.3	1311	0.3	2340
TOTALS	0.8	3004	1.0	4152	0.95	7411

Table 7-7 - Victim Search/Assistance Mission - 371 km (Rotary-Wing)

	HH-60		V-22/V-22 w/JSAFT [1]		V-22/V-22 w/JSAFT [2]	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARMUP	0.25	1324	0.25	1950	0.25	1950
ENROUTE	1.4	7416	0.8	6241	0.8	6241
LOCATION (37 KM SEARCH)	0.2	1059	0.1	780	0.2	1560
RTB	1.4	7416	0.8	6241	0.8	6241
TOTALS	3.25	17215	1.95	15212	2.05	15992

1 Fixed-wing mode during search

2 Rotary-wing mode during search

Table 7-8 - Victim Search/Assistance Mission - 371 km (Fixed - Wing)

	HU-25		HC-130	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARMUP	0.25	1001	0.25	1093
ENROUTE	0.5	2003	0.7	3060
LOCATION (37 KM SEARCH)	0.1	401	0.1	437
RTB	0.5	2003	0.7	3060
TOTALS	1.4	5407	1.8	7649

Table 7-9 - Victim Search/Assistance Mission - 741 km

	HU-25		HC-130		V-22 w/JSAFT [1]		V-22 w/JSAFT [2]	
MISSION PHASE	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST	TIME (HR)	GHSR-O COST
WARMUP	0.25	1001	0.25	1093	0.25	1950	0.25	1950
ENROUTE	1.1	4406	1.4	6119	1.6	12482	1.6	12482
LOCATION (37 KM SEARCH)	0.1	401	0.1	437	0.1	780	0.2	1560
RTB	1.1	4406	1.4	6119	1.6	12482	1.6	12482
TOTALS	2.6	10213	3.2	13769	3.55	27694	3.65	28474

1 Fixed-wing mode during search

2 Rotary-wing mode during search

In the cases examined, the HU-25 is the most cost effective alternative for these purely search missions. This is due to the significantly lower GHSR-O attributed to this aircraft. The HC-130 is second followed by the HH-65 (for the short range case). The V-22 alternatives are next and the HH-60 is least cost effective. The V-22 w/JSAFT would have to reduce its costs on the average approximately $4530 per hour to approach the cost effectiveness of the HU-25 and approximately $4080 per hour to approach the effectiveness of the HC-130. For ranges beyond the capability of the HU-25, the HC-130 remains more cost effective than the V-22.

7.1.3 SAR Summary

The higher GHSR-O Cost attributed to the V-22 makes it less cost effective than the current aircraft/helicopter alternatives for most of the missions examined. The V-22 is most cost effective when providing capabilities not resident in current alternatives such as long range victim extraction. These capabilities would enhance Coast Guard SAR capability 5 to 10%. The effect of the higher

speed of the V-22 on the survival rate was not evaluated in this analysis and future study in this area may be warranted.

7.2 LE/MI Cost and Operational Effectiveness Results

The operational effectiveness of USCG assets in the LE/MI scenario depends on the area the aircraft can search in order to detect the vessel traffic and the time on station devoted to monitoring suspect vessel. The results from two phases are combined with the the outside government hourly standard rate (GHSR-O) developed in Section 6.0 to determine the most cost effective aircraft alternative for each phase.

The first phase examined is the search phase. For this analysis, two specific cases are evaluated. The first case is the scenario where the aircraft has to travel 100 km enroute to the search area and monitors the vessels in an area of 10,000 km2. In the second case, the aircraft has to travel 600 km enroute to the search area and monitors the vessels in an area of 3500 km2. The first case examines data from all of the aircraft alternatives, while the second case looks at data from the HH-60, the HU-25, the HC-130, and the V-22 alternatives. The HH-65 does not have enough fuel necessary to perform the second case. The data for these two cases are depicted in Table 7-10.

Table 7-10 - LE/MI Search Phase Cost Effectiveness Results

	HH-65	HH-60	HU-25	HC-130	V-22 / V-22 w/JSAFT
Case 1 (Enroute 100 km; 10,000 km^2 Search Area)					
Mission Time (Hours)	2.88	2.62	1.12	1.30	1.42
Mission GHSR-O Cost ($)	11,173	13,878	4,470	5,663	11,045
Case 2 (Enroute 600 km; 3,500 km^2 Search Area)					
Mission Time (Hours)	-	5.27	2.00	2.63	2.94
Mission GHSR-O Cost ($)	-	27,930	7,992	11,502	22,905

The most cost effective aircraft alternative for the search phase of the LE/MI scenario is the HU-25. The HU-25 performs both scenario cases in the shortest amount of time due to its high velocity used to fly enroute to the search area. It is also the lowest cost fixed-wing aircraft alternative. The cost effectiveness of the remaining aircraft alternatives are, in descending order, the HC-130, the V-22, the HH-65, and the HH-60. The V-22 has the third best mission time performance which results in the third most cost effective alternative. It should also be noted that the utility of the landbased helicopters is limited by the range and the area that they can search.

The second phase examined is the monitor phase. For this analysis, two specific cases are evaluated. The first case is the scenario where the aircraft has to travel 100 km to intercept the suspect vessel and remains on station over the vessel for 2 hours. In the second case, the aircraft has to travel 600 km to intercept the target vessel and remains on station for 0.5 hour. The first case examines data from all of the aircraft alternatives, while the second case looks at data from the HH-60, the HU-25, the HC-130, and the V-22 alternatives. The HH-65 does not have enough fuel necessary to perform the second case. The data for these two cases are depicted in Table 7-11.

Table 7-11 - LE/MI Monitor Phase Cost Effectiveness Results

	HH-65	HH-60	HU-25	HC-130	V-22 / V-22 w/JSAFT
Case 1 (Enroute 100 km, 2 HR Time on Station)					
Mission Time (Hours)	2.80	2.77	2.28	2.39	2.43
Mission GHSR-O Cost ($)	10,862	14,678	9,148	10,427	18,972
Case 2 (Enroute 600 km, 0.5 HR Time on Station)					
Mission Time (Hours)	-	5.13	2.20	2.81	3.09
Mission GHSR-O Cost ($)	-	27,151	8,828	12,295	24,119

The most cost effective aircraft alternative for the monitor phase of the LE/MI scenario is the HU-25. The HU-25 performs both scenario cases in the shortest amount of time due to its high velocity used to intercept the suspect vessel and return to its home base upon completion of the mission. It is also the lowest cost fixed-wing aircraft alternative. For the first case, the cost effectiveness of the remaining aircraft alternatives are, in descending order, the HC-130, the HH-65, the HH-60, and the V-22. For the second case, the V-22 is more cost effective than the HH-60. This cost effectiveness reversal is due to the time spent traveling to and from the suspect vessel. For the first case, the time spent traveling is less than one hour for both alternatives; therefore, the cost savings afforded by the HH-60 directly translates to a more cost effective alternative. For the second case, the travel times are 2.6 hours and 4.6 hours for the V-22 and the HH-60, respectively. The V-22 time savings in this case overcomes the HH-60 cost savings, thus making the V-22 more cost effective than the HH-60. It should also be noted again that the utility of the landbased helicopters is limited by the range and the time spent on station over the vessel.

7.3 MEP Cost and Operational Effectiveness Results

The operational effectiveness of USCG assets in the MEP scenario depends on the time necessary to transport the MEP equipment from the strike force location to the staging area, the time to transport the equipment from the staging area to the spill site, and the area that each aircraft

alternative can monitor to gather information on the oil slick. The results from these three phases are combined with the outside Government Hourly Standard Rate (GHSR-O) developed in Section 6.0 to determine the most cost effective aircraft alternative for each phase.

The first phase evaluated is transporting the MEP equipment from the strike force location to the staging area. The dimensions of the equipment used to contain oil slicks are too great for most of the aircraft alternatives. Only HC-130s, tractor-trailers, and V-22s can be used to transport the equipment. Furthermore, only the HC-130 and the V-22 are examined in this phase. Two transporting to the staging area cases are considered. In the first case, the aircraft has to carry all of the equipment to a staging area that is 400 km from the strike force location; the second case is the scenario where all of the equipment is transported 1600 km. The data for these two cases are depicted in Table 7-12. The HC-130 is the most cost effective aircraft alternative to transport the MEP equipment to the staging area due to both the shorter total mission time and the lower operating costs.

Table 7-12 - MEP Transport to Staging Area Phase Cost Effectiveness Results

	HC-130	V-22
Case 1 (400 km to Staging Area)		
Mission Time (Hours)	7.71	22.70
Mission GHSR-O Cost ($)	33,698	177,101
Case 2 (1600 km to Staging Area)		
Mission Time (Hours)	30.84	90.81
Mission GHSR-O Cost ($)	134,793	708,405

The second phase evaluated is transporting the MEP equipment from the staging area to the spill site. Although USCG helicopters have a limited capability to sling load some equipment to a ship or remote site, the weight and the dimensions of the most of the equipment used to contain oil slicks generally exceeds the capabilities of these aircraft. Therefore, only the tractor-trailer and the V-22 are examined in this phase. Two transporting to the spill site cases are considered. For both cases, the distances traveled by the tractor-trailer are 25% greater than the distances traveled by the V-22. The delta in distances traveled reflects the fact that the V-22 can fly directly to the spill site while the tractor-trailer must follow roads that are often not the most direct route. In the first case, the V-22 has to carry all of the equipment to a spill site that is 50 km from the staging area, and the tractor-trailer has to carry all of the equipment 62.5 km. The second case is the scenario where all of the equipment is transported 200 km by the V-22, while all of the equipment is transported 250 km by the tractor-trailer. The data for these two cases are depicted in Table 7-13. Since the

costing data are not available for the tractor-trailer, there is no direct cost effectiveness comparison between the V-22 and the tractor-trailer.

Table 7-13 - MEP Transport to Spill Site Phase Cost Effectiveness Results

	Tractor-trailer	V-22
Case 1 [50 km to Spill Site for V-22, 62.5 km to Spill Site for Tractor-trailer (1:1.25 distance ratio)]		
Mission Time (Hours)	5.65	2.84
Mission GHSR-O Cost ($)	-	22,138
Case 2 [200 km to Spill Site for V-22, 250 km to Spill Site for Tractor-trailer (1:1.25 distance ratio)]		
Mission Time (Hours)	22.58	11.35
Mission GHSR-O Cost ($)	-	88,551

The third phase examined is the monitor the oil slick phase. For this analysis, two specific cases are evaluated. The first case is the scenario where the aircraft has to travel 50 km enroute to the spill site and monitors an area of 15,000 km2. In the second case, the aircraft has to travel 200 km enroute to the spill site and monitors an area of 7,500 km2. The data for these two cases are depicted in Table 7-14.

Table 7-14 - MEP Monitor Oil Slick Phase Cost Effectiveness Results

	HH-65	HH-60	HU-25	HC-130	V-22 / V-22 w/JSAFT
Case 1 (Enroute 50 km; 15,000 km2 Search Area)					
Mission Time (Hours)	2.86	2.57	1.13	1.25	1.36
Mission GHSR-O Cost ($)	11,094	13,623	4,509	5,457	10,588
Case 2 (Enroute 200 km; 7,500 km2 Search Area)					
Mission Time (Hours)	2.83	2.64	1.06	1.30	1.43
Mission GHSR-O Cost ($)	10,976	13,958	4,245	5,677	11,191

The most cost effective aircraft alternative for the monitor the oil slick phase of the MEP scenario is the HU-25. The HU-25 performs both scenario cases in the shortest amount of time due to its high velocity used to fly enroute to the search area. It is also the lowest cost fixed-wing aircraft alternative. The cost effectiveness of the remaining aircraft alternatives for the first case, in descending order, are: the HC-130, the V-22, the HH-65, and the HH-60. For the second case, the HH-65 is more cost effective than the V-22. This cost effectiveness reversal is due to the total mission time. The HH-65 total mission time slightly decreased while the V-22 mission time slightly increased from the first case to the second case. These small changes occur due to the differences in the velocities for enroute and monitoring the oil slick and the varying distances traveled to the monitor area. It should also be noted that the utility of the landbased helicopters is limited by the range and area that they can monitor

7.4 Cost and Operational Effectiveness Summary

The V-22 enjoys an operational effectiveness advantage over the baseline aircraft alternatives in some mission components. These advantages evaporate when combined with the outside government hourly standard rate in all cases except for one, i.e., the SAR victim extraction case at 371 km. In all of the other cases/scenarios examined, the V-22 is not the most cost effective aircraft alternative. In the SAR scenario, the HH-65 is the most cost effective alternative for the 148 km victim extraction case, followed by the fixed-wing V-22 alternatives. In the 371 km victim extraction case, the fixed-wing V-22 alternatives are the most cost effective followed by the rotary-wing V-22 alternatives. In the enroute and search phases of the SAR scenario, the MEP scenario, and the LE/MI scenario, the HU-25 followed by the HC-130 are the most cost effective alternatives. In these cases, the V-22 costs more than twice the amount of the HU-25 and about 1.5 times the cost of the HC-130.

Section 8.0
Conclusions

The U.S. Coast Guard has very specialized functions over a broad area of responsibility. They have adapted their aircraft procurement process to provide aircraft assets that can support multiple mission components at specific range intervals. The primary aircraft for short range missions is the HH-65. Depending on whether high speed is a requirement, medium range missions utilize either the HH-60 or HU-25. The HC-130H aircraft is the primary long range asset. Analysis of the mission scenarios used in this study lead to some general conclusions and to specific conclusions that are scenario dependent.

In general, the tiltrotor technology, as represented by the V-22, offers some distinct advantages over the baseline helicopter fleet due to its ability to cruise at fixed-wing airspeeds, to operate at greater distances, and to transport more cargo/personnel than either the HH-65 or the HH-60. In addition, the fixed-wing capabilities of the V-22 are, for the most part, equal to or slightly better than the HU-25. The greater speed of the HU-25 is generally offset by the greater operational radius and the mission flexibility provided by the dual role (helicopter and fixed-wing) capacity of the V-22. When these general advantages are applied to the specific missions of the Coast Guard, the V-22 capabilities match USCG capabilities, in most cases. The V-22 also offers an operational flexibility currently provided only by combinations of current aircraft as well as offering an operational capability in SAR in terms of range and payload which is not currently achievable.

In the Search and Rescue mission, the tiltrotor technology exemplified by the V-22 appeared to offer a set of characteristics that would have a significant application to the mission. The helicopter mode coupled with the speed and range of a fixed-wing aircraft could extend the full SAR mission performance beyond the range limits of the baseline helicopter force. The response standard of two hours could be met at distances double the HH-60 range and only slightly less than the range of the HU-25. The fuel capacity advantages of the HC-130 and the V-22 with JSAFT provided an advantage in the area searched, with the extra fuel of the HC-130H providing capability well beyond the cases examined. The exceptional passenger carrying capability of the V-22 provides the opportunity to handle major disasters at a significant distance from the launch point when compared to the helicopter alternatives. In comparison to the fixed-wing aircraft, the V-22 possesses the ability to extract victims which these alternatives lack. However, while long distance and large passenger capacity in themselves are significant advantages, the utility of these features may be marginal when examined in the context of the historical SAR data base. The data

base indicates that over 90% of all SAR missions occur within 37 km of the coast, and that 76% of those involving potential loss of life or property occur within 185 km of a CGAS and 95% within 556 km of a CGAS. In addition, in the incidents involving extraction of victims, 90% of the incidents involved 4 or fewer people. The principle advantage derived from the V-22 capabilities appear to apply to 5-10% of the total number of incidents. Therefore, the results of this study indicate that the applications of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of search and rescue at sea offers a marginal increase in effectiveness over the current baseline systems. This conclusion is contingent on whether future flight testing demonstrates a viable operational capability of hoist extraction of personnel from open water.

The scenario for the Law Enforcement mission area was directed by Congress to focus on drug interdiction. This mission can be further divided into interdiction of illegal drugs being transported by air or interdiction of illegal drugs being transported by sea. The latter case was chosen as being more representative of the Coast Guard's major role in this area. The role of aircraft in this mission, however, is limited to searching for the seaborne drug carrier and tracking the vessel until a Coast Guard cutter can be vectored into the area. The apprehension portion of this mission is exclusively the responsibility of the cutter. Once again, the greater fuel capacity and higher speeds of the V-22 results in significant advantages over the helicopter fleet. If a search area of 38,000 km^2 is used as a basis of comparison, then at 100 km from the launch point, one HC-130, V-22, V-22 with JSAFT, or HU-25 aircraft would be required to patrol this area while requiring two HH-60 or four HH-65 aircraft to satisfy this standard. However, when utilized, deployment of HH-60 and HH-65 aboard cutters eliminates the transit to the search area and increases the area which can be searched. Once the suspected drug boat has been located, the higher cruise speed of the HU-25 results in a quicker intercept. This advantage is marginally important, however, due to the slow speed of the target. Even at a 300 km intercept, the 0.5 hour time advantage of the HU-25 only translates to a 14 km traverse of the target given the 28 km/hr. speed of the vessel in the scenario. Finally, the V-22 capability of conversion from fixed-wing to rotary-wing flight gives it a qualitative advantage over the HU-25 and the HC-130H in maintaining track of slower moving boat traffic without significantly reducing time on station. Therefore, the results of this study indicate that the application of tiltrotor technology, as represented by the V-22, to the Coast Guard mission component of enforcement of the laws of the United States, especially with the respect to maritime drug interdiction offers an operational effectiveness equivalent to several of the baseline systems.

In the Marine Environmental Protection mission area, the scenario chosen is the incident response scenario focused on an oil spill. This accounted for the greatest percentage of incidence responses by the National Strike Force in 1992. This scenario is divided into three elements for assessment. In the phase associated with the transportation of oil spill equipment to a staging area, the only aircraft currently capable of performing this mission is the HC-130H and the V-22. The cargo carrying capability and range of the HC-130H dominate the results. Even when the necessary oil spill equipment is broken down into units compatible with the cargo capability of the V-22, the V-22 requires 12 lifts compared to 5 lifts for the HC-130H for the equipment it can carry. In the phase associated with movement of equipment from the staging area to the spill site, the V-22 offers an advantage over other helicopter assets which are not able to carry the equipment, and over the more nominal case of using overland transportation. At 50 km, the V-22 saves 1.7 hours when compared to the tractor-trailer in transporting all the equipment to the spill site. The possible advantage of using the V-22 to transport equipment directly from its initial location at the strike force to the spill site versus using an intermediate staging area as required by the HC-130H case was also examined. For these cases, the results appear to be dominated by the time saved using the HC-130H; and therefore, there appears to be no advantage in using the V-22. However, in the monitor phase of the mission, the fuel capacity of the V-22 with JSAFT enables it to equal or exceed the capabilities of all other air assets studied except for the HC-130H. Therefore, the results of this study indicate that the use of tiltrotor technology, as represented by the V-22, in the Coast Guard Marine Environment Program would contribute to minimizing the damage caused by oil or other hazardous substances spills in the waters of the United States.

Analysis of the cost data provided by the Naval Air System Command and the U.S. Coast Guard indicates that the V-22 is projected to be approximately 1.5 times more expensive to operate than the baseline helicopter aircraft. This relationship results primarily from the cost estimating relationships based on unit flyaway cost and aircraft weight empty cost, both of which are projected to be roughly double that of the HH-60. The analysis of the relationship of the V-22 to the fixed-wing alternatives also indicates that the V-22 is more expensive to operate than both the fixed-wing baseline alternatives. The manpower analysis shows that the V-22 requires more personnel than the HU-25 and the HH-65 and fewer personnel than the HH-60 and HC-130.

In all of the cases/scenarios examined, except for the SAR victim extraction case at 371 km, the V-22 is not the most cost effective aircraft alternative. In the SAR scenario, the HH-65 is the most cost effective alternative for the 148 km victim extraction case, followed by the V-22 alternatives. In the 371 km victim extraction case, the V-22 alternatives are the most cost effective. In the enroute and search phases of the SAR scenario, the MEP scenario, and the LE/MI scenario,

the HU-25 followed by the HC-130 are the most cost effective alternatives. In these cases, the V-22 costs more than twice the amount of the HU-25 and about 1.5 times the cost of the HC-130. Therefore, the results of this study indicate that tiltrotor technology, as represented by the V-22, would have the effect of substantially increasing U. S. Coast Guard operating costs over current baseline aircraft while having a negligible effect on manpower costs across the current baseline fleet.

Appendix A

Documents Referenced

"International Convention for the Prevention of Pollution from Ships," 1973.

"National Oil and Hazardous Substances Pollution Contingency Plan," Federal Register, 55, no. 46, March 1990, Part 300.

Ball, J.C., LCDR USN and Bowes, R.H., USN/USMC Assessment of the XV-15 Tiltrotor Research Aircraft, RW-29R-83, Naval Air Test Center, Patuxent River, MD, 26 September 1983.

BDM Corporation, MV-22 Combat Effectiveness Analysis, McClean, VA, March 1987.

BDM International, Inc., "MV-22 Combat Effectiveness Analysis," McClean, VA, April 1990.

Boeing Defense and Space Group, "Potential Mission Applications of the V-22 for the United States Coast Guard," Wilmington, DE, 19 February 1993. (Briefing)

Boeing Helicopters, "MV-22 Mission Effectiveness Analysis in Support of Headquarters, USMC (Aviation Plans and Programs)," May 1991.

Boeing Helicopters, "Special Operations, BH Overview," April 18, 1990.

Boeing Helicopters, "U.S. Coast Guard SAR Study, Missions/Rotary Wing Aircraft Analysis," Philadelphia, PA, March 1990.

Boeing Helicopters, "V-22 in the Medevac Role, Modelling Support for the U.S. Army," May, 1991.

Center for Naval Analyses, Cost and Operational Effectiveness Analysis of JVX for Marine Corps Assault Mission, CNR-104, Center for Naval Analyses, Alexandria, VA, August 1985.

Center for Naval Analyses, SV-22 Cost and Effectiveness Study, CNR-147, 2 vols., Center for Naval Analyses, Alexandria, VA, March 1988.

Crouch, H.F., Col., "But What if We'd Had the Osprey?," Marine Corps Gazette, September 1991.

Flight Manual C-130, USCG Series Aircraft, C.G.T.O. 1C-130-1, 6 November 1986.

Flight Manual, U.S. Coast Guard, Series HH-65A Helicopter, C.G.T.O. 1H-65A-1, 19 November 1990 with revision 1, 16 January 1992.

Flight Manual, USAF Series C-130 Airplanes Equipped with T56-A-15 Engines, T01C-130H-1-1, 5 May 1986 with Change 4, 21 February 1992.

Flight Manual, USCG, HU-25 Aircraft, C.G.T.O. 1U-25A-1, 1 January 1990.

Gray, M.; Croisetiere, P. Maj USMC; and Bonin , J., Maj USAF, V-22 Aircraft Navy Development Test DT-IIC, RW-26R-92, Naval Air Warfare Center Aircraft Division, Patuxent River, MD, 30 December 1991.

Hammes, G., Maj USMC, and Kracinovich, S., et al., MV-22 Aircraft, Navy Development Test DT-IIA, RW-71R-90, Naval Air Test Center, Patuxent River, MD, 15 February 1991.

Lambert, Ronald A. and Bortell, J. Thomas, United States Coast Guard Surveillance Requirements Document, Environmental Research Institute, Ann Arbor, MI, 13 April 1992 (Review Copy).

Meyerhoff, C., MV-22 Qualitative Rotor Downwash Evaluation, RW-15R-91, Naval Air Test Center, Patuxent River, MD, 22 March 1991.

Mitchell, T.R. and Kusek, L.J., Cost and Operational Effectiveness Analysis of the JVX for the Combat Search-and-Rescue Mission, CRM 85-76, Center for Naval Analyses, Alexandria, VA, August 1985.

NATOPS Flight Manual, Coast Guard Model HH-60J Aircraft, A1-H60JA-NFM-000, 15 November 1989 with Change 2, 15 December 1991..

NATOPS Flight Manual, Navy Model, MV-22A Aircraft, A1-V22AA-NFM-000, 15 February 1992 (Preliminary Draft).

NKF Engineering, Inc., "V-22 ASW Variant Shipboard Compatibility Study," Arlington, VA, 15 August 1986.

Porter, S., "V-22 Development at Patuxent River,", Naval Air Test Center, Patuxent River, MD, February 18, 1993, (Briefing).

Price, R., Maj USMC; Croisetiere, P., Maj USMC; Hammes, G., Maj USMC; Levoci, P., LCDR USN; VanderVliet, G.; et al., MV-22 Aircraft, Navy Development Test DT-IIB, RW-21R-91, Naval Air Test Center, Patuxent River, MD, 16 July 1991.

Prime, K.S., LCDR USN, "What's so Good about Probability of Success," National SAR School, Yorktown, VA, 25 March 1993.

Thompson, G., CDR, USN, "V-22 Overview for United States Coast Guard," Washington, DC, 27 January 1993, (Briefing).

U.S. Coast Guard Commandant (G-CFM) memorandum, "Standard Personnel Cost (SPC) Tables," Washington, DC, 20 April 1993.

U.S. Coast Guard, "National Strike Force Equipment Manual."

U.S. Coast Guard, Commandant (G-NRS) memorandum, "SAR Program Standards," Washington, DC, 11 January 1993.

U.S. Coast Guard, Commandant (G-MP) memorandum, "FY95 Budget Cycles/Issues," Washington, DC, November 13, 1992.

U.S. Coast Guard, Commandant (G-OAV) memorandum, "Coast Guard FY 92 Aircraft Utilization," Washington, DC, 25 March 1993.

U.S. Coast Guard, Commandant (G-OAV) memorandum, "Congressionally Mandated Study of the V-22 Tiltrotor Aircraft," Washington, DC, January 13, 1993.,

U.S. Coast Guard, Commandant (G-OAV) memorandum, "FY- 93/94 Aviation Management Plan," Washington, DC.

U.S. Coast Guard, Commandant Instruction 16000.21, "The Commandant's Strategic Agenda," Washington, DC, 21 September 1990.

U.S. Coast Guard, Commandant Instruction M5230.10A, "Search and Rescue Management Information Manual," Washington, DC, 10 January 1992.

U.S. Coast Guard, Commandant Instruction M13020.1C, "Aeronautical Engineering Maintenance Manual," Washington, DC, Draft.

U.S. Coast Guard, Commandant Instruction M13520.7A, "Rescue and Survival Equipment Manual," Washington, DC.

U.S. Coast Guard, Commandant Instruction M16000.11, "Marine Safety Manual, Vol. VI: Ports and Waterways Activities," 27 June 1986.

U.S. Coast Guard, Commandant Instruction M16000.6, "Marine Safety Manual, Vol. I: Administration and Management," 5 May 1986.

U.S. Coast Guard, Commandant Instruction M16120.5, "National Search and Rescue Manual," Washington, DC, 1 August 1986.

U.S. Coast Guard, Commandant Publication P16107.6, "SAR Statistics-1991," Washington, DC, 15 May 1992.

U.S. Coast Guard, Commandant Publication P16700.4, "Navigation and Vessel Inspection Circulars," #7-92 and #8-92, Washington, DC, September 15,1992.

U.S. Coast Guard, Marine Safety Office, Baltimore, MD, "On-Scene Coordinator Regional Response Team Exercise," February 1991.

U.S. Coast Guard, Marine Safety Office, Providence and Group/COTP Long Island Sound, "On-Scene Coordinator Regional Response Team Simulation," April 1991.

U.S. Coast Guard, Marine Safety Office, San Francisco Bay, "On-Scene Coordinator Regional Response Team Simulation," June 1991.

U.S. Coast Guard, Research and Development Center, Program Advisory Group Inputs, January 18, 1993.

U.S. Coast Guard, U.S. Coast Guard Aircraft, Abstract of Operations, Fiscal Year: 1992 Summary, Washington, DC, 16 November 1992.

U.S. Congress. House. Committee on Appropriations, Coast Guard Authorization Fiscal Year 1993 Report, 102nd Congress, 2d session, 1992 .

U.S. Congress. House. Committee on Appropriations. Institute for Defense Analysis Study of V-22 Osprey. Hearing before a subcommittee of the Committee of Appropriations, 101st Congress, 2d session, 1990.

Warshawsky, A.S.; Olness, D.V.; Pimper, J.E.; Uzelac, M.J.; and Wilson, J., Effectiveness of Tiltrotor Support to Ground Combat, UCRL-ID-106416, Lawrence Livermore National Laboratory, Livermore, CA, January, 1991.

Appendix B
Data Analysis

This appendix contains the input data used for each scenario along with the resulting output data. Section B.1 contains the data for the Search and Rescue (SAR) scenario. Section B.2 contains the Law Enforcement/Maritime Interdiction (LE/MI) scenario data, and the Marine Environmental Protection (MEP) scenario data are stored in Section B.3. An explanation of the data, the assumptions behind the data, and the results are presented in Section 5.0.

B.1 Search and Rescue (SAR) Data

The following pages contain the equations used for the analysis and the resulting outputs generated from this analysis of the tiltrotor technology in the USCG SAR scenario. The equations are shown below in an outline form, and mirror the SAR Analysis Methodology discussed in Section 5.1.3.

Listed below are constant values used in the analysis obtained through interviews of operational USCG pilots at USCG Air Stations Elizabeth City and Miami:

a. Victim Extraction Rate (E) - 5 minutes per victim
b. Initial Response Time - 30 minutes

Listed below are descriptions of terms used in the analysis formulas:

T_E	Enroute time
D_E	Enroute distance
V_E	Enroute velocity
T_S	Search time
D_S	Search distance
V_S	Search velocity
T_R (Vict)	Rescue time based on the number of victims
Vict	# of victims to be extracted
T_R (F)	Rescue time based on fuel quantity
F_R	Rescue fuel
F_T	Total fuel
F_{ST}	Start-up fuel
Bingo fuel	Fuel required to return to base and safely land
F_E	Enroute fuel
F_S	Search fuel
FF_E	Enroute fuel flow
FF_S	Search fuel flow
FF_R	Rescue fuel flow
F_{Land}	Remaining fuel required on landing
Max Area	Maximum area searched
Max D_S	Maximum search distance
Max T_S	Maximum search time
Max F_S	Maximum search fuel available

The following formulas were used in the analysis:

Enroute Time (T_E)	D_E / V_E
Time on station (TOS)	$T_S + T_R$
Search Time (T_S)	D_S / V_S
Rescue Time (T_R (Vict))	Vict * E
Rescue time (T_R (F))	F_R / FF_R
Rescue fuel (F_R)	F_T - F_{ST} - F_E - F_S - Bingo
Fuel enroute (F_E)	$FF_E * T_E$
Search fuel (F_S)	$FF_S * T_S$
Bingo fuel	$F_{Land} + F_E$
Max Area Searched (Max Area)	Max D_S * W
Max Search Distance (Max D_S)	Max T_S * V_S
Max Search Time (Max T_S)	Max F_S / FF_S
Max Search Fuel (Max F_S)	F_T - F_{ST} - F_E - Bingo

The following calculations were used in the analysis.

a. Enroute time (T_E) calculation.

1) Obtain the enroute airspeeds (V_E) for each aircraft type from Table 5-2.
2) Enroute Time (T_E) = D_E / V_E
3) The return distance from the rescue site to an aid station is considered to be the same as the enroute distance.

b. Time on station (TOS) calculation.

1) Calculate the TOS using the following formula:
   Time on station (TOS) = $T_S + T_R$
2) If the search distance is greater than zero, which implies a search is required, then calculate the search time (T_S) using the following formula: Search Time (T_S) = D_S / V_S
3) Calculate the time required to rescue the victims (based on the number of victims, which is a run matrix variable) using the following formula: Rescue Time (T_R (Vict)) = Vict * E

4) Calculate time available to rescue victims as a function of available fuel using the following formula: Rescue time (T_R (F)) $=F_R / FF_R$

a) Calculate the rescue fuel using the following formula:
Rescue fuel (F_R) = F_T - F_{ST} - F_E - F_S - Bingo

b) Calculate enroute fuel (F_E) using the following formula:
Fuel enroute (F_E) = FF_E * T_E

c) Calculate the search fuel using the following formula:
Search fuel (F_S) = FF_S * T_S

d) Calculate bingo fuel using the following formula:
Bingo fuel = F_{Land}+ F_E

5) The actual rescue time is the smaller of the two rescue times.

6) The TOS may also be only the time spent searching if the victims cannot be found. This is the maximum search area the aircraft can cover.

a) Calculate the maximum search area possible using the following formula: Max Area Searched (AREA) = Max D_S * W

b) Calculate Max D_S using the following formula:
Max Search Distance (Max D_S) = Max T_S * V_S

c) Calculate Max T_S using the following formula:
Max Search Time (Max T_S) = Max F_S / FF_S

d) Calculate Max F_S using the following formula:
Max Search Fuel (Max F_S) = F_T - F_{STT} - F_E - Bingo.

SAR SCENARIO SPREADSHEET

FIGURE 5-4 ENROUTE TIME VS ENROUTE DISTANCE

ENROUTE DISTANCE (KM)	HH-60	HH-65	HU-25	HC-130	V-22	JSAFT
37	0.2	0.2	0.1	0.1	0.1	0.1
148	0.6	0.6	0.2	0.3	0.3	0.3
185	0.8	0.8	0.3	0.4	0.4	0.4
278	1.2	1.2	0.4	0.6	0.6	0.6
371	1.6	1.6	0.6	0.8	0.8	0.8
483	2		0.7	1	1	1
556	2.4		0.8	1.2	1.2	1.2
649			1	1.4	1.4	1.4
741			1.1	1.6	1.6	1.6
834			1.3	1.8	1.8	1.8
927			1.4	2	2	2
1019				2.2	2.2	2.2
1112				2.4		2.4
1204				2.6		2.6
1297				2.8		2.8
2370				5.1		

FIGURE 5-5 SEARCH TIME REQUIRED TO FIND VICTIMS

Search Distance	H-60	H-65	HU-25	HC-130	V-22	V-22*	JSAFT	JSAFT*
37 KM	1.4	1.4	0.8	0.9	0.9	1.0	0.9	1.0
148 KM	2.0	2.0	1.2	1.3	1.2	1.7	1.2	1.7
371 KM	3.4	3.4	1.8	1.9	1.9	3.0	1.9	3.0
741 KM	5.6		2.9	3.0	3.0		3.0	

* HELO SEARCH MODE

FIGURE 5-6 MAXIMUM SEARCH AREA CAPABILITY

	V-22*	HH-65	JSAFT*	HH-60	V-22	JSAFT	HU-25	HC-130
KM2	2978	3191	3720	5447	6975	8711	8789	19450

RUN MATRIX VARIABLES							
ENROUTE DISTANCE (km)	148	80					
NUMBER OF VICTIMS	3						
SEARCH DISTANCE (km)	37	20					
# OF TRIPS TO RESCUE	1						
PARAMETERS	**UNITS**	**H-60**	**H-65**	**HU-25**	**C-130**	**V-22**	**JSAFT**
ENROUTE TIME	hrs	0.6	0.6	0.2	0.3	0.3	0.3
RESPONSE TIME	hrs	1.1	1.1	0.7	0.8	0.8	0.8
SEARCH TIME	hrs	0.2	0.2	0.1	0.1	0.1	0.1
SEARCH TIME (HELO MODE)	hrs					0.2	0.2
RESCUE TIME(Vict)	hrs	0.3	0.3			0.3	0.3
RESCUE TIME(Fuel)	hrs	3.0	1.4			2.3	3.2
RESCUE TIME	hrs	0.3	0.3			0.3	0.3
TIME ON STATION	hrs	0.5	0.5	0.1	0.1	0.4	0.4
TIME ON STA (HELO MODE)	hrs					0.5	0.5
SORTIE TIME	hrs	2.2	2.2	1.1	1.3	1.5	1.5
SORTIE TIME (HELO MODE)	hrs					1.6	1.6
ENROUTE FUEL	kg	327.7	150.8	259.1	817.7	382.0	392.2
SEARCH FUEL	kg	91.7	42.4	56.6	194.4	111.7	118.3
SEARCH FUEL (HELO MODE)	kg					335.5	355.1
RESCUE FUEL USED	kg	161.5	68.0			483.0	483.0
RESCUE FUEL(AVAIL)	kg	1,947.0	386.0			4,516.3	6,226.3
FUEL REMAINING	kg	2,285.2	547.8	3,999.3	27,064.9	4,813.3	6,544.5
FUEL REMAINING (HELO MODE)	kg					4,589.5	6,307.7
BINGO FUEL	kg	499.7	229.8	1,133.1	2,733.7	780.0	801.2
MAX SEARCH TIME	hrs	4.9	2.2	5.7	14.0	4.6	6.0
MAX SEARCH DISTANCE	km	824.4	374.6	1,914.1	4,675.5	1,535.0	1,987.9
MAX SEARCH AREA	km2	4,121.8	1,873.0	7,465.0	18,234.6	5,986.6	7,752.8
MAX SRCH TIME (HELO MODE)	hrs					3.1	4.0
MAX SRCH DIST (HELO MODE)	km					511.2	662.2
MAX SRCH AREA (HELO MODE)	km2					2,555.8	3,311.1
MAX PASSENGERS	#	6	3			24	18
VICTIMS RESCUED	#	3	3			3	3
VICTIMS REMAINING	#	0	0			0	0
FIND TIME	hrs	1.4	1.4	0.8	0.9	0.9	0.9
FIND TIME (HELO MODE)	hrs					1.0	1.0

RUN MATRIX VARIABLES							
ENROUTE DISTANCE (km)	148	80					
NUMBER OF VICTIMS	3						
SEARCH DISTANCE (km)	148	80					
# OF TRIPS TO RESCUE	1						
PARAMETERS	**UNITS**	**H-60**	**H-65**	**HU-25**	**C-130**	**V-22**	**JSAFT**
ENROUTE TIME	hrs	0.6	0.6	0.2	0.3	0.3	0.3
RESPONSE TIME	hrs	1.1	1.1	0.7	0.8	0.8	0.8
SEARCH TIME	hrs	0.9	0.9	0.4	0.4	0.4	0.4
SEARCH TIME (HELO MODE)	hrs					0.9	0.9
RESCUE TIME(Vict)	hrs	0.3	0.3			0.3	0.3
RESCUE TIME(Fuel)	hrs	2.6	1.0			2.2	3.0
RESCUE TIME	hrs	0.3	0.3			0.3	0.3
TIME ON STATION	hrs	1.1	1.1	0.4	0.4	0.7	0.7
TIME ON STA (HELO MODE)	hrs					1.1	1.1
SORTIE TIME	hrs	2.9	2.9	1.4	1.6	1.8	1.8
SORTIE TIME (HELO MODE)	hrs					2.3	2.3
ENROUTE FUEL	kg	327.7	150.8	259.1	817.7	382.0	392.2
SEARCH FUEL	kg	366.6	169.5	226.4	777.6	446.9	473.1
SEARCH FUEL (HELO MODE)	kg					1,342.1	1,420.3
RESCUE FUEL USED	kg	161.5	68.0			483.0	483.0
RESCUE FUEL(AVAIL)	kg	1,672.1	258.9			4,181.1	5,871.5
FUEL REMAINING	kg	2,010.2	420.7	3,829.5	26,481.7	4,478.1	6,189.7
FUEL REMAINING (HELO MODE)	kg					3,582.9	5,242.5
BINGO FUEL	kg	499.7	229.8	1,133.1	2,733.7	780.0	801.2
MAX SEARCH TIME	hrs	4.9	2.2	5.7	14.0	4.6	6.0
MAX SEARCH DISTANCE	km	824.4	374.6	1,914.1	4,675.5	1,535.0	1,987.9
MAX SEARCH AREA	km2	4,121.8	1,873.0	7,465.0	18,234.6	5,986.6	7,752.8
MAX SRCH TIME (HELO MODE)	hrs					3.1	4.0
MAX SRCH DIST (HELO MODE)	km					511.2	662.2
MAX SRCH AREA (HELO MOD	km2					2,555.8	3,311.1
MAX PASSENGERS	#	6	3			24	18
VICTIMS RESCUED	#	3	3			3	3
VICTIMS REMAINING	#	0	0			0	0
FIND TIME	hrs	2.0	2.0	1.2	1.3	1.3	1.3
FIND TIME (HELO MODE)	hrs					1.7	1.7

RUN MATRIX VARIABLES							
ENROUTE DISTANCE (km)	148	80					
NUMBER OF VICTIMS	3						
SEARCH DISTANCE (km)	371	200					
# OF TRIPS TO RESCUE	1						
PARAMETERS	**UNITS**	**H-60**	**H-65**	**HU-25**	**C-130**	**V-22**	**JSAFT**
ENROUTE TIME	hrs	0.6	0.6	0.2	0.3	0.3	0.3
RESPONSE TIME	hrs	1.1	1.1	0.7	0.8	0.8	0.8
SEARCH TIME	hrs	2.2	2.2	1.1	1.1	1.1	1.1
SEARCH TIME (HELO MODE)	hrs					2.2	2.2
RESCUE TIME(Vict)	hrs	0.3	0.3			0.3	0.3
RESCUE TIME(Fuel)	hrs	1.7	0.0			1.8	2.7
RESCUE TIME	hrs	0.3	0.0			0.3	0.3
TIME ON STATION	hrs	2.5	2.2	1.1	1.1	1.4	1.4
TIME ON STA (HELO MODE)	hrs					2.5	2.5
SORTIE TIME	hrs	4.2	4.0	2.1	2.2	2.5	2.5
SORTIE TIME (HELO MODE)	hrs					3.6	3.6
ENROUTE FUEL	kg	327.7	150.8	259.1	817.7	382.0	392.2
SEARCH FUEL	kg	916.5	423.9	565.9	1,944.0	1,117.3	1,182.8
SEARCH FUEL (HELO MODE)	kg					3,355.4	3,550.7
RESCUE FUEL USED	kg	161.5	4.6			483.0	483.0
RESCUE FUEL(AVAIL)	kg	1,122.2	4.6			3,510.7	5,161.8
FUEL REMAINING	kg	1,460.3	229.8	3,490.0	25,315.3	3,807.7	5,480.0
FUEL REMAINING (HELO MODE)	kg					1,569.7	3,112.1
BINGO FUEL	kg	499.7	229.8	1,133.1	2,733.7	780.0	801.2
MAX SEARCH TIME	hrs	4.9	2.2	5.7	14.0	4.6	6.0
MAX SEARCH DISTANCE	km	824.4	374.6	1,914.1	4,675.5	1,535.0	1,987.9
MAX SEARCH AREA	km2	4,121.8	1,873.0	7,465.0	18,234.6	5,986.6	7,752.8
MAX SRCH TIME (HELO MODE)	hrs					3.1	4.0
MAX SRCH DIST (HELO MODE)	km					511.2	662.2
MAX SRCH AREA (HELO MOD	km2					2,555.8	3,311.1
MAX PASSENGERS	#	6	3			24	18
VICTIMS RESCUED	#	3	0			3	3
VICTIMS REMAINING	#	0	3			0	0
FIND TIME	hrs	3.4	3.4	1.8	1.9	1.9	1.9
FIND TIME (HELO MODE)	hrs					3.0	3.0

RUN MATRIX VARIABLES							
ENROUTE DISTANCE (km)	148	80					
NUMBER OF VICTIMS	3						
SEARCH DISTANCE (km)	741	400					
# OF TRIPS TO RESCUE	1						
PARAMETERS	**UNITS**	**H-60**	**H-65**	**HU-25**	**C-130**	**V-22**	**JSAFT**
ENROUTE TIME	hrs	0.6	0.6	0.2	0.3	0.3	0.3
RESPONSE TIME	hrs	1.1	1.1	0.7	0.8	0.8	0.8
SEARCH TIME	hrs	4.4	4.4	2.2	2.2	2.2	2.2
SEARCH TIME (HELO MODE)	hrs					4.4	4.4
RESCUE TIME(Vict)	hrs	0.3	0.3			0.3	0.3
RESCUE TIME(Fuel)	hrs	0.3	0.0			1.2	2.1
RESCUE TIME	hrs	0.3	0.0			0.3	0.3
TIME ON STATION	hrs	4.7	4.4	2.2	2.2	2.5	2.5
TIME ON STA (HELO MODE)	hrs					4.7	4.7
SORTIE TIME	hrs	6.5	6.2	3.2	3.4	3.6	3.6
SORTIE TIME (HELO MODE)	hrs					5.8	5.8
ENROUTE FUEL	kg	327.7	150.8	259.1	817.7	382.0	392.2
SEARCH FUEL	kg	1,833.0	847.7	1,131.8	3,888.0	2,234.7	2,365.6
SEARCH FUEL (HELO MODE)	kg					6,710.7	7,101.3
RESCUE FUEL USED	kg	161.5	0.0			483.0	483.0
RESCUE FUEL(AVAIL)	kg	205.7	0.0			2,393.4	3,979.0
FUEL REMAINING	kg	543.8	(189.5)	2,924.1	23,371.3	2,690.3	4,297.2
FUEL REMAINING (HELO MODE)	kg					(1,785.7)	(438.5)
BINGO FUEL	kg	499.7	229.8	1,133.1	2,733.7	780.0	801.2
MAX SEARCH TIME	hrs	4.9	2.2	5.7	14.0	4.6	6.0
MAX SEARCH DISTANCE	km	824.4	374.6	1,914.1	4,675.5	1,535.0	1,987.9
MAX SEARCH AREA	km2	4,121.8	1,873.0	7,465.0	18,234.6	5,986.6	7,752.8
MAX SRCH TIME (HELO MODE)	hrs					3.1	4.0
MAX SRCH DIST (HELO MODE)	km					511.2	662.2
MAX SRCH AREA (HELO MOD	km2					2,555.8	3,311.1
MAX PASSENGERS	#	6	3			24	18
VICTIMS RESCUED	#	3	0			3	3
VICTIMS REMAINING	#	0	3			0	0
FIND TIME	hrs	5.6	5.6	2.9	3.0	3.0	3.0
FIND TIME (HELO MODE)	hrs					5.3	5.3

B.2 Law Enforcement/Maritime Interdiction (LE/MI) Data

The following pages contain the equations used for the analysis and the resulting outputs generated from this of the tiltrotor technology in the LE/MI scenario. The equations, which correspond to the LE/MI Analysis Methodology, are shown below:

1. Calculate the maximum search area that each aircraft can monitor and the time it takes to search that area:

a. Obtain the aircraft performance data necessary from Table 5-4.

b. Calculate the time and the fuel required to fly enroute to the search.

(1) Vary distances traveled from takeoff to search from 100 to 800 km.

(2) Enroute time (T_E) = distance to search area/enroute velocity.

(3) Enroute fuel (F_E) = T_E * enroute fuel flow.

c. Calculate the fuel remaining for the search.

(1) Total mission fuel = total usable fuel - reserve fuel - landing fuel - start-up fuel.

(2) Search fuel (F_S) = total mission fuel - (2 * F_E).

d. Calculate the time remaining for the search and the maximum area that can be searched in this time.

(1) Search time (T_S) = F_S / search fuel flow.

(2) Search area = search width * TS * search velocity.

e. Calculate the total search mission time = TS + (2 * T_E).

2. Calculate the time required to intercept the targeted vessel and the time on station, i.e., the time that the aircraft can track the vessel.

a. Obtain the aircraft performance data necessary from Table 5-4.

b. Calculate the time and fuel required to fly enroute to the vessel.

(1) Vary distances traveled from takeoff to the vessel from 100 to 800 km.

(2) Enroute time (T_E) = distance to vessel / enroute velocity.

(3) Enroute fuel (F_E) = T_E * enroute fuel flow.

c. Calculate the fuel remaining for the time on station over the vessel.

(1) Total mission fuel = total usable fuel - reserve fuel - landing fuel - start-up fuel.

(2) Time on station fuel (F_{TOS}) = total mission fuel - (2 * F_E).

d. Calculate the time remaining for the time on station.

(1) Time on station (T_{TOS}) = F_{TOS} / time on station fuel flow.

e. Calculate the total track mission time = TTOS + (2 * T_E).

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	100	100	100	100	100	100
Time to search area (hr)	0.215983	0.215983	0.215983	0.429185	0.429185	0.149925
Enroute fuel (kg)	257.6674	264.5788	551.6199	221.03	101.7167	174.8126
Search fuel (kg)	4876.775	6599.672	25058.6	2251.94	526.2065	3091.375
Search time (hr)	4.842875	6.191062	14.30285	5.452639	2.755008	6.061519
Search area (km2)	47959.48	61310.71	141642.6	29489.79	14900.05	60027.83
Total mission time (hr)	5.274841	6.623028	14.73482	6.311008	3.613377	6.361369
Track Vessel						
Dist to intercept (km)	100	100	100	100	100	100
Intercept time (hr)	0.215983	0.215983	0.215983	0.429185	0.429185	0.149925
Intercept fuel (kg)	257.6674	264.5788	551.6199	221.03	101.7167	174.8126
TOS fuel (kg)	4876.775	6599.672	25058.6	2251.94	526.2065	3091.375
TOS time (hr)	4.842875	6.191062	14.28655	5.452639	2.755008	6.061519
Total mission time (hr)	5.274841	6.623028	14.71851	6.311008	3.613377	6.361369
Inputs						
Dist to search area (km)	100					
Dist to intercept (km)	100					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	200	200	200	200	200	200
Time to search area (hr)	0.431965	0.431965	0.431965	0.858369	0.858369	0.29985
Enroute fuel (kg)	515.3348	529.1577	1103.24	442.0601	203.4335	349.6252
Search fuel (kg)	4361.44	6070.515	23955.36	1809.88	322.773	2741.75
Search time (hr)	4.331123	5.694667	13.67315	4.382276	1.689911	5.37598
Search area (km2)	42891.54	56394.85	135406.6	23700.89	9139.633	53238.86
Total mission time (hr)	5.195053	6.558598	14.53708	6.099014	3.406649	5.97568
Track Vessel						
Dist to intercept (km)	200	200	200	200	200	200
Intercept time (hr)	0.431965	0.431965	0.431965	0.858369	0.858369	0.29985
Intercept fuel (kg)	515.3348	529.1577	1103.24	442.0601	203.4335	349.6252
TOS fuel (kg)	4361.44	6070.515	23955.36	1809.88	322.773	2741.75
TOS time (hr)	4.331123	5.694667	13.65756	4.382276	1.689911	5.37598
Total mission time (hr)	5.195053	6.558598	14.52149	6.099014	3.406649	5.97568
Inputs						
Dist to search area (km)	200					
Dist to intercept (km)	200					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	300	300	300	300	300	300
Time to search area (hr)	0.647948	0.647948	0.647948	1.287554	1.287554	0.449775
Enroute fuel (kg)	773.0022	793.7365	1654.86	663.0901	305.1502	524.4378
Search fuel (kg)	3846.106	5541.357	22852.12	1367.82	119.3396	2392.124
Search time (hr)	3.81937	5.198271	13.04345	3.311912	0.624815	4.69044
Search area (km2)	37823.6	51479	129170.6	17911.98	3379.216	46449.9
Total mission time (hr)	5.115266	6.494167	14.33934	5.88702	3.199922	5.58999
Track Vessel						
Dist to intercept (km)	300	300	300	300	300	300
Intercept time (hr)	0.647948	0.647948	0.647948	1.287554	1.287554	0.449775
Intercept fuel (kg)	773.0022	793.7365	1654.86	663.0901	305.1502	524.4378
TOS fuel (kg)	3846.106	5541.357	22852.12	1367.82	119.3396	2392.124
TOS time (hr)	3.81937	5.198271	13.02858	3.311912	0.624815	4.69044
Total mission time (hr)	5.115266	6.494167	14.32447	5.88702	3.199922	5.58999
Inputs						
Dist to search area (km)	300					
Dist to intercept (km)	300					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect,ID,Monitor						
Dist to search area (km)	400	400	400	400	400	400
Time to search area (hr)	0.863931	0.863931	0.863931	1.716738	1.716738	0.5997
Enroute fuel (kg)	1030.67	1058.315	2206.479	884.1202	406.867	699.2504
Search fuel (kg)	3330.771	5012.199	21748.88	925.7597	-84.0939	2042.499
Search time (hr)	3.307618	4.701876	12.41374	2.241549	-0.44028	4.0049
Search area (km2)	32755.67	46563.14	122934.6	12123.08	-2381.2	39660.93
Total mission time (hr)	5.035479	6.429737	14.14161	5.675025	2.993194	5.204301
Track Vessel						
Dist to intercept (km)	400	400	400	400	400	400
Intercept time (hr)	0.863931	0.863931	0.863931	1.716738	1.716738	0.5997
Intercept fuel (kg)	1030.67	1058.315	2206.479	884.1202	406.867	699.2504
TOS fuel (kg)	3330.771	5012.199	21748.88	925.7597	-84.0939	2042.499
TOS time (hr)	3.307618	4.701876	12.39959	2.241549	-0.44028	4.0049
Total mission time (hr)	5.035479	6.429737	14.12745	5.675025	2.993194	5.204301
Inputs						
Dist to search area (km)	400					
Dist to intercept (km)	400					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	500	500	500	500	500	500
Time to search area (hr)	1.079914	1.079914	1.079914	2.145923	2.145923	0.749625
Enroute fuel (kg)	1288.337	1322.894	2758.099	1105.15	508.5837	874.063
Search fuel (kg)	2815.436	4483.042	20645.64	483.6996	-287.527	1692.874
Search time (hr)	2.795865	4.20548	11.78404	1.171185	-1.50538	3.319361
Search area (km2)	27687.73	41647.29	116698.5	6334.182	-8141.62	32871.96
Total mission time (hr)	4.955692	6.365307	13.94387	5.463031	2.786467	4.818611
Track Vessel						
Dist to intercept (km)	500	500	500	500	500	500
Intercept time (hr)	1.079914	1.079914	1.079914	2.145923	2.145923	0.749625
Intercept fuel (kg)	1288.337	1322.894	2758.099	1105.15	508.5837	874.063
TOS fuel (kg)	2815.436	4483.042	20645.64	483.6996	-287.527	1692.874
TOS time (hr)	2.795865	4.20548	11.77061	1.171185	-1.50538	3.319361
Total mission time (hr)	4.955692	6.365307	13.93043	5.463031	2.786467	4.818611
Inputs						
Dist to search area (km)	500					
Dist to intercept (km)	500					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	600	600	600	600	600	600
Time to search area (hr)	1.295896	1.295896	1.295896	2.575107	2.575107	0.89955
Enroute fuel (kg)	1546.004	1587.473	3309.719	1326.18	610.3004	1048.876
Search fuel (kg)	2300.101	3953.884	19542.4	41.63948	-490.961	1343.249
Search time (hr)	2.284113	3.709084	11.15434	0.100822	-2.57048	2.633821
Search area (km2)	22619.8	36731.43	110462.5	545.2808	-13902	26083
Total mission time (hr)	4.875905	6.300877	13.74613	5.251037	2.579739	4.432922
Track Vessel						
Dist to intercept (km)	600	600	600	600	600	600
Intercept time (hr)	1.295896	1.295896	1.295896	2.575107	2.575107	0.89955
Intercept fuel (kg)	1546.004	1587.473	3309.719	1326.18	610.3004	1048.876
TOS fuel (kg)	2300.101	3953.884	19542.4	41.63948	-490.961	1343.249
TOS time (hr)	2.284113	3.709084	11.14162	0.100822	-2.57048	2.633821
Total mission time (hr)	4.875905	6.300877	13.73341	5.251037	2.579739	4.432922
Inputs						
Dist to search area (km)	600					
Dist to intercept (km)	600					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	700	700	700	700	700	700
Time to search area (hr)	1.511879	1.511879	1.511879	3.004292	3.004292	1.049475
Enroute fuel (kg)	1803.672	1852.052	3861.339	1547.21	712.0172	1223.688
Search fuel (kg)	1784.767	3424.726	18439.16	-400.421	-694.394	993.6237
Search time (hr)	1.77236	3.212689	10.52464	-0.96954	-3.63557	1.948282
Search area (km2)	17551.86	31815.58	104226.5	-5243.62	-19662.5	19294.03
Total mission time (hr)	4.796118	6.236447	13.54839	5.039042	2.373011	4.047232
Track Vessel						
Dist to intercept (km)	700	700	700	700	700	700
Intercept time (hr)	1.511879	1.511879	1.511879	3.004292	3.004292	1.049475
Intercept fuel (kg)	1803.672	1852.052	3861.339	1547.21	712.0172	1223.688
TOS fuel (kg)	1784.767	3424.726	18439.16	-400.421	-694.394	993.6237
TOS time (hr)	1.77236	3.212689	10.51264	-0.96954	-3.63557	1.948282
Total mission time (hr)	4.796118	6.236447	13.53639	5.039042	2.373011	4.047232
Inputs						
Dist to search area (km)	700					
Dist to intercept (km)	700					

LE/MI Worksheet

Constant data						
	V-22	V-22/tank	C-130	HH-60	HH-65	HU-25
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166
TOS fuel flow (kg/hr)	1007	1066	1754	413	191	510
Total useable fuel (kg)	5835.11	7582.83	28531.44	2930	854	4536
Landing fuel (kg)	398	409	1916	172	79	874
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221
Mission fuel (kg)	5392.11	7128.83	26161.84	2694	729.64	3441
Search velocity (km/hr)	334	334	334	166.77	166.77	334
Enroute velocity (km/hr)	463	463	463	233	233	667
TOS velocity (km/hr)	334	334	334	166.77	166.77	334
Sweep width (km)	29.65	29.65	29.65	32.43	32.43	29.65
Detect						
Dist to search area (km)	800	800	800	800	800	800
Time to search area (hr)	1.727862	1.727862	1.727862	3.433476	3.433476	1.1994
Enroute fuel (kg)	2061.339	2116.631	4412.959	1768.24	813.7339	1398.501
Search fuel (kg)	1269.432	2895.569	17335.92	-842.481	-897.828	643.9985
Search time (hr)	1.260608	2.716293	9.894933	-2.0399	-4.70067	1.262742
Search area (km2)	12483.92	26899.72	97990.51	-11032.5	-25422.9	12505.06
Total mission time (hr)	4.716331	6.172017	13.35066	4.827048	2.166284	3.661543
Track Vessel						
Dist to intercept (km)	800	800	800	800	800	800
Intercept time (hr)	1.727862	1.727862	1.727862	3.433476	3.433476	1.1994
Intercept fuel (kg)	2061.339	2116.631	4412.959	1768.24	813.7339	1398.501
TOS fuel (kg)	1269.432	2895.569	17335.92	-842.481	-897.828	643.9985
TOS time (hr)	1.260608	2.716293	9.88365	-2.0399	-4.70067	1.262742
Total mission time (hr)	4.716331	6.172017	13.33937	4.827048	2.166284	3.661543
Inputs						
Dist to search area (km)	800					
Dist to intercept (km)	800					

B.3 Marine Environmental Protection (MEP) Data

The following pages contain the equations used for the analysis and the resulting outputs generated from this analysis on the tiltrotor technology in the USCH MEP scenario. The equations, which correspond to the MEP Analysis Methodology, are shown below:

1. Cargo capacity calculations.

   a. Obtain the dimensions of the cargo bay and the weight limits of the transporting aircraft and tractor-trailers (for transporting to the spill site).

   b. Obtain the dimensions and weights of the MEP equipment.

   c. Determine whether the equipment can be carried on all of the aircraft alternatives and the tractor-trailers.

      (1) Calculate the number of lifts required for each alternative.

2. Staging area calculations

   a. Obtain the aircraft performance data necessary from Table 5-7.

   b. Calculate the time required to transport one load of equipment to the staging area.

      (1) Vary distance travelled from strike team location to the staging area from 400 to 2000 km.

      (2) Time for one load of equipment (T_{1LOAD}) = (distance to staging area / loaded velocity) + (return distance to strike team location / enroute velocity).

   c. Calculate the time required to transport all of the equipment to the staging area.

      (1) Time for all loads (T_{ALL}) = T_{1LOAD} * number of lifts to transport all of equipment.

3. Spill site calculations

a. Obtain the aircraft performance data necessary from Table 5-7.

b. Calculate the time required to transport one load of equipment to the spill site.

(1) Vary distance travelled from staging area to the spill site from 50 to 250 km.

(2) Time for one load of equipment (T_{1LOAD}) = (distance to spill site / loaded velocity) + (return distance to staging area / enroute velocity).

c. Calculate the time required to transport all of the equipment to the spill site.

(1) Time for all loads (T_{ALL}) = T_{1LOAD} * number of lifts to transport all of equipment.

4. Oil slick monitoring calculations.

a. Obtain the aircraft performance data necessary from Table 5-7.

b. Calculate the time and fuel required to fly to the oil slick.

(1) Vary distances traveled from takeoff to search area from 50 to 250 km.

(2) Enroute time (T_E) = distance to spill / enroute velocity.

(3) Enroute fuel (F_E) = T_E * enroute fuel flow.

c. Calculate the fuel remaining for monitoring/searching for the oil slick.

(1) Total mission fuel = total usable fuel - reserve fuel - landing fuel - start-up fuel.

(2) Search fuel (F_S) = total mission fuel - (2 * F_E).

d. Calculate the time remaining for monitoring/searching for the oil slick and the maximum area that can be searched in this time.

(1) Search time (T_S) = F_S / search fuel flow.

(2) Search area = search width * T_S * search velocity.

(3) Search area covered in one hour = sweep width * 1 hour * search velocity.

e. Calculate the total monitor/search mission time = $T_S + (2 * T_E)$.

MEP Worksheet

Constant data	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	400	400	400	400	400	400	400
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	1.9166	1.9166	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Time for all equip (hr)	22.999	22.999	9.4087	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Spill site							
Dist to spill site (km)	50	50	50	50	50	50	50
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	0.2396	0.2396	0.2352	#DIV/0!	#DIV/0!	#DIV/0!	1.1291
Time for all equip (hr)	2.8748	2.8748	1.1761	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Search area							
Dist to spill site (km)	50	50	50	50	50	50	50
Search fuel (kg)	5134.4	6864.3	25610	2473	627.92	3266.2	136.81
Enroute time (hr)	0.108	0.108	0.108	0.2146	0.2146	0.075	0.5645
Search time (hr)	5.0988	6.4393	14.618	5.9878	3.2876	6.4043	#DIV/0!
Search area (km2)	65292	82458	187188	41082	22556	82011	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.3147	6.6552	14.834	6.417	3.7167	6.5542	#DIV/0!
Inputs							
Dist to staging area (km)	400						
Dist to spill site (km)	50						
# aircraft available	1						
#lifts / #ac	12	12	5				4

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	800	800	800	800	800	800	800
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	3.8331	3.8331	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Time for all equip (hr)	45.997	45.997	18.817	#DIV/0!	#DIV/0!	#DIV/0!	72.259
Spill site							
Dist to spill site (km)	100	100	100	100	100	100	100
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	0.4791	0.4791	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Time for all equip (hr)	5.7497	5.7497	2.3522	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Search area							
Dist to spill site (km)	100	100	100	100	100	100	100
Search fuel (kg)	4876.8	6599.7	25059	2251.9	526.21	3091.4	119.4
Enroute time (hr)	0.216	0.216	0.216	0.4292	0.4292	0.1499	1.1291
Search time (hr)	4.8429	6.1911	14.303	5.4526	2.755	6.0615	#DIV/0!
Search area (km2)	62016	79280	183156	37410	18902	77621	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2748	6.623	14.735	6.311	3.6134	6.3614	#DIV/0!
Inputs							
Dist to staging area (km)	800						
Dist to spill site (km)	100						
# aircraft available	1						
#lifts / #ac	12	12	5				4

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1200	1200	1200	1200	1200	1200	1200
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	5.7497	5.7497	5.6452	#DIV/0!	#DIV/0!	#DIV/0!	27.097
Time for all equip (hr)	68.996	68.996	28.226	#DIV/0!	#DIV/0!	#DIV/0!	108.39
Spill site							
Dist to spill site (km)	150	150	150	150	150	150	150
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	0.7187	0.7187	0.7057	#DIV/0!	#DIV/0!	#DIV/0!	3.3872
Time for all equip (hr)	8.6245	8.6245	3.5283	#DIV/0!	#DIV/0!	#DIV/0!	13.549
Search area							
Dist to spill site (km)	150	150	150	150	150	150	150
Search fuel (kg)	4619.1	6335.1	24507	2030.9	424.49	2916.6	101.99
Enroute time (hr)	0.324	0.324	0.324	0.6438	0.6438	0.2249	1.6936
Search time (hr)	4.587	5.9429	13.988	4.9175	2.2225	5.7187	#DIV/0!
Search area (km2)	58739	76102	179124	33738	15248	73232	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2349	6.5908	14.636	6.205	3.51	6.1685	#DIV/0!
Inputs							
Dist to staging area (km)	1200						
Dist to spill site (km)	150						
# aircraft available	1						
#lifts / #ac	12	12	5				4

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1600	1600	1600	1600	1600	1600	1600
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	7.6662	7.6662	7.527	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Time for all equip (hr)	91.995	91.995	37.635	#DIV/0!	#DIV/0!	#DIV/0!	144.52
Spill site							
Dist to spill site (km)	200	200	200	200	200	200	200
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	0.9583	0.9583	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Time for all equip (hr)	11.499	11.499	4.7044	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Search area							
Dist to spill site (km)	200	200	200	200	200	200	200
Search fuel (kg)	4361.4	6070.5	23955	1809.9	322.77	2741.7	84.58
Enroute time (hr)	0.432	0.432	0.432	0.8584	0.8584	0.2999	2.2581
Search time (hr)	4.3311	5.6947	13.673	4.3823	1.6899	5.376	#DIV/0!
Search area (km2)	55462	72923	175092	30066	11594	68842	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1951	6.5586	14.537	6.099	3.4066	5.9757	#DIV/0!
Inputs							
Dist to staging area (km)	1600						
Dist to spill site (km)	200						
# aircraft available	1						
#lifts / #ac	12	12	5				4

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	2000	2000	2000	2000	2000	2000	2000
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	9.5828	9.5828	9.4087	#DIV/0!	#DIV/0!	#DIV/0!	45.162
Time for all equip (hr)	114.99	114.99	47.044	#DIV/0!	#DIV/0!	#DIV/0!	180.65
Spill site							
Dist to spill site (km)	250	250	250	250	250	250	250
# aircraft available	1	1	1	1	1	1	1
Time/equip load (hr)	1.1979	1.1979	1.1761	#DIV/0!	#DIV/0!	#DIV/0!	5.6453
Time for all equip (hr)	14.374	14.374	5.8804	#DIV/0!	#DIV/0!	#DIV/0!	22.581
Search area							
Dist to spill site (km)	250	250	250	250	250	250	250
Search fuel (kg)	4103.8	5805.9	23404	1588.8	221.06	2566.9	67.17
Enroute time (hr)	0.54	0.54	0.54	1.073	1.073	0.3748	2.8226
Search time (hr)	4.0752	5.4465	13.358	3.8471	1.1574	5.0332	#DIV/0!
Search area (km2)	52186	69745	171061	26395	7940.6	64453	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1552	6.5264	14.438	5.993	3.3033	5.7828	#DIV/0!
Inputs							
Dist to staging area (km)	2000						
Dist to spill site (km)	250						
# aircraft available	1						
#lifts / #ac	12	12	5				4

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	400	400	400	400	400	400	400
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	1.9166	1.9166	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Time for all equip (hr)	11.499	11.499	5.6452	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Spill site							
Dist to spill site (km)	50	50	50	50	50	50	50
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	0.2396	0.2396	0.2352	#DIV/0!	#DIV/0!	#DIV/0!	1.1291
Time for all equip (hr)	1.4374	1.4374	0.7057	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Search area							
Dist to spill site (km)	50	50	50	50	50	50	50
Search fuel (kg)	5134.4	6864.3	25610	2473	627.92	3266.2	136.81
Enroute time (hr)	0.108	0.108	0.108	0.2146	0.2146	0.075	0.5645
Search time (hr)	5.0988	6.4393	14.618	5.9878	3.2876	6.4043	#DIV/0!
Search area (km2)	65292	82458	187188	41082	22556	82011	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.3147	6.6552	14.834	6.417	3.7167	6.5542	#DIV/0!
Inputs							
Dist to staging area (km)	400						
Dist to spill site (km)	50						
# aircraft available	2						
#lifts / #ac	6	6	3				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	800	800	800	800	800	800	800
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	3.8331	3.8331	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Time for all equip (hr)	22.999	22.999	11.29	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Spill site							
Dist to spill site (km)	100	100	100	100	100	100	100
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	0.4791	0.4791	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Time for all equip (hr)	2.8748	2.8748	1.4113	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Search area							
Dist to spill site (km)	100	100	100	100	100	100	100
Search fuel (kg)	4876.8	6599.7	25059	2251.9	526.21	3091.4	119.4
Enroute time (hr)	0.216	0.216	0.216	0.4292	0.4292	0.1499	1.1291
Search time (hr)	4.8429	6.1911	14.303	5.4526	2.755	6.0615	#DIV/0!
Search area (km2)	62016	79280	183156	37410	18902	77621	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2748	6.623	14.735	6.311	3.6134	6.3614	#DIV/0!
Inputs							
Dist to staging area (km)	800						
Dist to spill site (km)	100						
# aircraft available	2						
#lifts / #ac	6	6	3				2

MEP WorkSheet , 7/22/93

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1200	1200	1200	1200	1200	1200	1200
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	5.7497	5.7497	5.6452	#DIV/0!	#DIV/0!	#DIV/0!	27.097
Time for all equip (hr)	34.498	34.498	16.936	#DIV/0!	#DIV/0!	#DIV/0!	54.194
Spill site							
Dist to spill site (km)	150	150	150	150	150	150	150
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	0.7187	0.7187	0.7057	#DIV/0!	#DIV/0!	#DIV/0!	3.3872
Time for all equip (hr)	4.3123	4.3123	2.117	#DIV/0!	#DIV/0!	#DIV/0!	6.7743
Search area							
Dist to spill site (km)	150	150	150	150	150	150	150
Search fuel (kg)	4619.1	6335.1	24507	2030.9	424.49	2916.6	101.99
Enroute time (hr)	0.324	0.324	0.324	0.6438	0.6438	0.2249	1.6936
Search time (hr)	4.587	5.9429	13.988	4.9175	2.2225	5.7187	#DIV/0!
Search area (km2)	58739	76102	179124	33738	15248	73232	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2349	6.5908	14.636	6.205	3.51	6.1685	#DIV/0!
Inputs							
Dist to staging area (km)	1200						
Dist to spill site (km)	150						
# aircraft available	2						
#lifts / #ac	6	6	3				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1600	1600	1600	1600	1600	1600	1600
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	7.6662	7.6662	7.527	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Time for all equip (hr)	45.997	45.997	22.581	#DIV/0!	#DIV/0!	#DIV/0!	72.259
Spill site							
Dist to spill site (km)	200	200	200	200	200	200	200
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	0.9583	0.9583	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Time for all equip (hr)	5.7497	5.7497	2.8226	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Search area							
Dist to spill site (km)	200	200	200	200	200	200	200
Search fuel (kg)	4361.4	6070.5	23955	1809.9	322.77	2741.7	84.58
Enroute time (hr)	0.432	0.432	0.432	0.8584	0.8584	0.2999	2.2581
Search time (hr)	4.3311	5.6947	13.673	4.3823	1.6899	5.376	#DIV/0!
Search area (km2)	55462	72923	175092	30066	11594	68842	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1951	6.5586	14.537	6.099	3.4066	5.9757	#DIV/0!
Inputs							
Dist to staging area (km)	1600						
Dist to spill site (km)	200						
# aircraft available	2						
#lifts / #ac	6	6	3				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	2000	2000	2000	2000	2000	2000	2000
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	9.5828	9.5828	9.4087	#DIV/0!	#DIV/0!	#DIV/0!	45.162
Time for all equip (hr)	57.497	57.497	28.226	#DIV/0!	#DIV/0!	#DIV/0!	90.324
Spill site							
Dist to spill site (km)	250	250	250	250	250	250	250
# aircraft available	2	2	2	2	2	2	2
Time/equip load (hr)	1.1979	1.1979	1.1761	#DIV/0!	#DIV/0!	#DIV/0!	5.6453
Time for all equip (hr)	7.1871	7.1871	3.5283	#DIV/0!	#DIV/0!	#DIV/0!	11.291
Search area							
Dist to spill site (km)	250	250	250	250	250	250	250
Search fuel (kg)	4103.8	5805.9	23404	1588.8	221.06	2566.9	67.17
Enroute time (hr)	0.54	0.54	0.54	1.073	1.073	0.3748	2.8226
Search time (hr)	4.0752	5.4465	13.358	3.8471	1.1574	5.0332	#DIV/0!
Search area (km2)	52186	69745	171061	26395	7940.6	64453	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1552	6.5264	14.438	5.993	3.3033	5.7828	#DIV/0!
Inputs							
Dist to staging area (km)	2000						
Dist to spill site (km)	250						
# aircraft available	2						
#lifts / #ac	6	6	3				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	400	400	400	400	400	400	400
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	1.9166	1.9166	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Time for all equip (hr)	7.6662	7.6662	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Spill site							
Dist to spill site (km)	50	50	50	50	50	50	50
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	0.2396	0.2396	0.2352	#DIV/0!	#DIV/0!	#DIV/0!	1.1291
Time for all equip (hr)	0.9583	0.9583	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Search area							
Dist to spill site (km)	50	50	50	50	50	50	50
Search fuel (kg)	5134.4	6864.3	25610	2473	627.92	3266.2	136.81
Enroute time (hr)	0.108	0.108	0.108	0.2146	0.2146	0.075	0.5645
Search time (hr)	5.0988	6.4393	14.618	5.9878	3.2876	6.4043	#DIV/0!
Search area (km2)	65292	82458	187188	41082	22556	82011	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.3147	6.6552	14.834	6.417	3.7167	6.5542	#DIV/0!
Inputs							
Dist to staging area (km)	400						
Dist to spill site (km)	50						
# aircraft available	3						
#lifts / #ac	4	4	2				2

MEP Worksheet

Constant data	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	800	800	800	800	800	800	800
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	3.8331	3.8331	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Time for all equip (hr)	15.332	15.332	7.527	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Spill site							
Dist to spill site (km)	100	100	100	100	100	100	100
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	0.4791	0.4791	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Time for all equip (hr)	1.9166	1.9166	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Search area							
Dist to spill site (km)	100	100	100	100	100	100	100
Search fuel (kg)	4876.8	6599.7	25059	2251.9	526.21	3091.4	119.4
Enroute time (hr)	0.216	0.216	0.216	0.4292	0.4292	0.1499	1.1291
Search time (hr)	4.8429	6.1911	14.303	5.4526	2.755	6.0615	#DIV/0!
Search area (km2)	62016	79280	183156	37410	18902	77621	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2748	6.623	14.735	6.311	3.6134	6.3614	#DIV/0!
Inputs							
Dist to staging area (km)	800						
Dist to spill site (km)	100						
# aircraft available	3						
#lifts / #ac	4	4	2				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1200	1200	1200	1200	1200	1200	1200
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	5.7497	5.7497	5.6452	#DIV/0!	#DIV/0!	#DIV/0!	27.097
Time for all equip (hr)	22.999	22.999	11.29	#DIV/0!	#DIV/0!	#DIV/0!	54.194
Spill site							
Dist to spill site (km)	150	150	150	150	150	150	150
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	0.7187	0.7187	0.7057	#DIV/0!	#DIV/0!	#DIV/0!	3.3872
Time for all equip (hr)	2.8748	2.8748	1.4113	#DIV/0!	#DIV/0!	#DIV/0!	6.7743
Search area							
Dist to spill site (km)	150	150	150	150	150	150	150
Search fuel (kg)	4619.1	6335.1	24507	2030.9	424.49	2916.6	101.99
Enroute time (hr)	0.324	0.324	0.324	0.6438	0.6438	0.2249	1.6936
Search time (hr)	4.587	5.9429	13.988	4.9175	2.2225	5.7187	#DIV/0!
Search area (km2)	58739	76102	179124	33738	15248	73232	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2349	6.5908	14.636	6.205	3.51	6.1685	#DIV/0!
Inputs							
Dist to staging area (km)	1200						
Dist to spill site (km)	150						
# aircraft available	3						
#lifts / #ac	4	4	2				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1600	1600	1600	1600	1600	1600	1600
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	7.6662	7.6662	7.527	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Time for all equip (hr)	30.665	30.665	15.054	#DIV/0!	#DIV/0!	#DIV/0!	72.259
Spill site							
Dist to spill site (km)	200	200	200	200	200	200	200
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	0.9583	0.9583	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Time for all equip (hr)	3.8331	3.8331	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Search area							
Dist to spill site (km)	200	200	200	200	200	200	200
Search fuel (kg)	4361.4	6070.5	23955	1809.9	322.77	2741.7	84.58
Enroute time (hr)	0.432	0.432	0.432	0.8584	0.8584	0.2999	2.2581
Search time (hr)	4.3311	5.6947	13.673	4.3823	1.6899	5.376	#DIV/0!
Search area (km2)	55462	72923	175092	30066	11594	68842	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1951	6.5586	14.537	6.099	3.4066	5.9757	#DIV/0!
Inputs							
Dist to staging area (km)	1600						
Dist to spill site (km)	200						
# aircraft available	3						
#lifts / #ac	4	4	2				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	2000	2000	2000	2000	2000	2000	2000
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	9.5828	9.5828	9.4087	#DIV/0!	#DIV/0!	#DIV/0!	45.162
Time for all equip (hr)	38.331	38.331	18.817	#DIV/0!	#DIV/0!	#DIV/0!	90.324
Spill site							
Dist to spill site (km)	250	250	250	250	250	250	250
# aircraft available	3	3	3	3	3	3	3
Time/equip load (hr)	1.1979	1.1979	1.1761	#DIV/0!	#DIV/0!	#DIV/0!	5.6453
Time for all equip (hr)	4.7914	4.7914	2.3522	#DIV/0!	#DIV/0!	#DIV/0!	11.291
Search area							
Dist to spill site (km)	250	250	250	250	250	250	250
Search fuel (kg)	4103.8	5805.9	23404	1588.8	221.06	2566.9	67.17
Enroute time (hr)	0.54	0.54	0.54	1.073	1.073	0.3748	2.8226
Search time (hr)	4.0752	5.4465	13.358	3.8471	1.1574	5.0332	#DIV/0!
Search area (km2)	52186	69745	171061	26395	7940.6	64453	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1552	6.5264	14.438	5.993	3.3033	5.7828	#DIV/0!
Inputs							
Dist to staging area (km)	2000						
Dist to spill site (km)	250						
# aircraft available	3						
#lifts / #ac	4	4	2				2

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	400	400	400	400	400	400	400
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	1.9166	1.9166	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Time for all equip (hr)	5.7497	5.7497	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	9.0324
Spill site							
Dist to spill site (km)	50	50	50	50	50	50	50
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	0.2396	0.2396	0.2352	#DIV/0!	#DIV/0!	#DIV/0!	1.1291
Time for all equip (hr)	0.7187	0.7187	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	1.1291
Search area							
Dist to spill site (km)	50	50	50	50	50	50	50
Search fuel (kg)	5134.4	6864.3	25610	2473	627.92	3266.2	136.81
Enroute time (hr)	0.108	0.108	0.108	0.2146	0.2146	0.075	0.5645
Search time (hr)	5.0988	6.4393	14.618	5.9878	3.2876	6.4043	#DIV/0!
Search area (km2)	65292	82458	187188	41082	22556	82011	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.3147	6.6552	14.834	6.417	3.7167	6.5542	#DIV/0!
Inputs							
Dist to staging area (km)	400						
Dist to spill site (km)	50						
# aircraft available	4						
#lifts / #ac	3	3	2				1

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	800	800	800	800	800	800	800
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	3.8331	3.8331	3.7635	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Time for all equip (hr)	11.499	11.499	7.527	#DIV/0!	#DIV/0!	#DIV/0!	18.065
Spill site							
Dist to spill site (km)	100	100	100	100	100	100	100
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	0.4791	0.4791	0.4704	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Time for all equip (hr)	1.4374	1.4374	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	2.2581
Search area							
Dist to spill site (km)	100	100	100	100	100	100	100
Search fuel (kg)	4876.8	6599.7	25059	2251.9	526.21	3091.4	119.4
Enroute time (hr)	0.216	0.216	0.216	0.4292	0.4292	0.1499	1.1291
Search time (hr)	4.8429	6.1911	14.303	5.4526	2.755	6.0615	#DIV/0!
Search area (km2)	62016	79280	183156	37410	18902	77621	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2748	6.623	14.735	6.311	3.6134	6.3614	#DIV/0!
Inputs							
Dist to staging area (km)	800						
Dist to spill site (km)	100						
# aircraft available	4						
#lifts / #ac	3	3	2				1

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1200	1200	1200	1200	1200	1200	1200
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	5.7497	5.7497	5.6452	#DIV/0!	#DIV/0!	#DIV/0!	27.097
Time for all equip (hr)	17.249	17.249	11.29	#DIV/0!	#DIV/0!	#DIV/0!	27.097
Spill site							
Dist to spill site (km)	150	150	150	150	150	150	150
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	0.7187	0.7187	0.7057	#DIV/0!	#DIV/0!	#DIV/0!	3.3872
Time for all equip (hr)	2.1561	2.1561	1.4113	#DIV/0!	#DIV/0!	#DIV/0!	3.3872
Search area							
Dist to spill site (km)	150	150	150	150	150	150	150
Search fuel (kg)	4619.1	6335.1	24507	2030.9	424.49	2916.6	101.99
Enroute time (hr)	0.324	0.324	0.324	0.6438	0.6438	0.2249	1.6936
Search time (hr)	4.587	5.9429	13.988	4.9175	2.2225	5.7187	#DIV/0!
Search area (km2)	58739	76102	179124	33738	15248	73232	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.2349	6.5908	14.636	6.205	3.51	6.1685	#DIV/0!
Inputs							
Dist to staging area (km)	1200						
Dist to spill site (km)	150						
# aircraft available	4						
#lifts / #ac	3	3	2				1

MEP Worksheet

Constant data	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	1600	1600	1600	1600	1600	1600	1600
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	7.6662	7.6662	7.527	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Time for all equip (hr)	22.999	22.999	15.054	#DIV/0!	#DIV/0!	#DIV/0!	36.13
Spill site							
Dist to spill site (km)	200	200	200	200	200	200	200
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	0.9583	0.9583	0.9409	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Time for all equip (hr)	2.8748	2.8748	1.8817	#DIV/0!	#DIV/0!	#DIV/0!	4.5162
Search area							
Dist to spill site (km)	200	200	200	200	200	200	200
Search fuel (kg)	4361.4	6070.5	23955	1809.9	322.77	2741.7	84.58
Enroute time (hr)	0.432	0.432	0.432	0.8584	0.8584	0.2999	2.2581
Search time (hr)	4.3311	5.6947	13.673	4.3823	1.6899	5.376	#DIV/0!
Search area (km2)	55462	72923	175092	30066	11594	68842	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1951	6.5586	14.537	6.099	3.4066	5.9757	#DIV/0!
Inputs							
Dist to staging area (km)	1600						
Dist to spill site (km)	200						
# aircraft available	4						
#lifts / #ac	3	3	2				1

MEP Worksheet

Constant data							
	V-22	V-22/t	C-130	HH-60	HH-65	HU-25	Truck
Max Gross Weight (kg)	21.6k VTO/25k STO		70308	9926.6	4037	14515	28123
Cargo bay dimensions (m)	7.4x2x2	7.4x2x2	12.5x3x3	-	-	-	12.2x2.4
Floor load factor (kg/m2)	1464.8	1464.8	-	-	-	-	-
Max cargo weight (kg)	9072	7324.3	18144	-	-	-	22680
Max ext cargo weight (kg)	6804	6804		2721.6	907.2		
# lifts for MEP equip	12	12	5				4
Search fuel flow (kg/hr)	1007	1066	1752	413	191	510	
Enroute fuel flow (kg/hr)	1193	1225	2554	515	237	1166	15.42
Loaded fuel flow (kg/hr)	1686	1686	2346				15.42
Total useable fuel (kg)	5835.1	7582.8	28531	2930	854	4536	154.22
Landing fuel (kg)	398	409	1916	172	79	874	
Start/warm-up fuel (kg)	45	45	453.6	64	45.36	221	
Mission fuel (kg)	5392.1	7128.8	26162	2694	729.64	3441	154.22
Search velocity (km/hr)	334	334	334	166.77	166.77	334	
Enroute velocity (km/hr)	463	463	463	233	233	667	88.57
Loaded velocity (km/hr)	380	380	393				88.57
Max dist to stage (km)	657	166	3507				886
Max dist to spill (km)	328.5	83	1753.5				443
Sweep width (km)	38.34	38.34	38.34	41.14	41.14	38.34	
Staging area							
Dist to staging area (km)	2000	2000	2000	2000	2000	2000	2000
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	9.5828	9.5828	9.4087	#DIV/0!	#DIV/0!	#DIV/0!	45.162
Time for all equip (hr)	28.748	28.748	18.817	#DIV/0!	#DIV/0!	#DIV/0!	45.162
Spill site							
Dist to spill site (km)	250	250	250	250	250	250	250
# aircraft available	4	4	4	4	4	4	4
Time/equip load (hr)	1.1979	1.1979	1.1761	#DIV/0!	#DIV/0!	#DIV/0!	5.6453
Time for all equip (hr)	3.5936	3.5936	2.3522	#DIV/0!	#DIV/0!	#DIV/0!	5.6453
Search area							
Dist to spill site (km)	250	250	250	250	250	250	250
Search fuel (kg)	4103.8	5805.9	23404	1588.8	221.06	2566.9	67.17
Enroute time (hr)	0.54	0.54	0.54	1.073	1.073	0.3748	2.8226
Search time (hr)	4.0752	5.4465	13.358	3.8471	1.1574	5.0332	#DIV/0!
Search area (km2)	52186	69745	171061	26395	7940.6	64453	#DIV/0!
Coverage rate (km2/hr)	12806	12806	12806	6860.9	6860.9	12806	0
Mission time (hr)	5.1552	6.5264	14.438	5.993	3.3033	5.7828	#DIV/0!
Inputs							
Dist to staging area (km)	2000						
Dist to spill site (km)	250						
# aircraft available	4						
#lifts / #ac	3	3	2				1

B.4 Manpower/Staffing Supporting Data

The manpower / staffing data that were used to support the calculations in Section 6.3 are listed in this appendix for each baseline aircraft alternative. The Coast Guard data for the staffing for a single base with a specific number of aircraft are displayed in the top set of charts. The number of bases which have that number of aircraft assigned is multiplied by the single base staffing to provide a total staffing for each basing pattern. The total staffing for each baseline aircraft alternative was the addition of the total staffing for each pattern utilized in the Coast Guard. The average per aircraft is calculated by dividing the total staffing by the fleet size.

APPENDIX B - 4						
COMPUTATION OF STAFFING FOR HH-60J						
SINGLE BASE INPUTS						
Coast	HH - 60 J			Coast	HH - 60 J	
Guard	3 PER STATION			Guard	4 PER STATION	
Input	OFFICER	ENLISTED		Input	OFFICER	ENLISTED
CREW	6	6		CREW	8	8
OTHER	7	45		OTHER	9	60
BOS	3	5		BOS	3	4
TOTAL	16	56		TOTAL	20	72
NUMBER OF				NUMBER OF		
BASES				BASES		
4				2		
	TOTAL				TOTAL	
	HH - 60 J				HH - 60 J	
	3 PER STATION				4 PER STATION	
	OFFICER	ENLISTED			OFFICER	ENLISTED
CREW	24	24		CREW	16	16
OTHER	28	180		OTHER	18	120
BOS	12	20		BOS	6	8
TOTAL	64	224		TOTAL	40	144
	FLEET OF 20				FLEET OF 20	
	HH - 60 J				HH - 60 J	
	TOTAL FOR 20				AVERAGE PER AIRCRAFT	
	OFFICER	ENLISTED			OFFICER	ENLISTED
CREW	40	40		CREW	2	2
OTHER	46	300		OTHER	2.3	15
BOS	18	28		BOS	0.9	1.4
TOTAL	104	368		TOTAL	5.2	18.4

APPENDIX B - 4

COMPUTATION OF STAFFING FOR C-130

SINGLE BASE INPUTS

Coast Guard Input	C - 130 3 PER STATION OFFICER	ENLISTED	Coast Guard Input	C - 130 4 PER STATION OFFICER	ENLISTED	Coast Guard Input	C - 130 6 PER STATION OFFICER	ENLISTED
CREW	6	15	CREW	8	20	CREW	12	30
OTHER	5	51	OTHER	8	68	OTHER	14	102
BOS	3	7	BOS	3	11	BOS	3	18
TOTAL	14	73	TOTAL	19	99	TOTAL	29	150

NUMBER OF BASES	NUMBER OF BASES	NUMBER OF BASES
2	2	2

	TOTAL C - 130 3 PER STATION OFFICER	ENLISTED		TOTAL C - 130 4 PER STATION OFFICER	ENLISTED		TOTAL C - 130 6 PER STATION OFFICER	ENLISTED
CREW	12	30	CREW	16	40	CREW	24	60
OTHER	10	102	OTHER	16	136	OTHER	28	204
BOS	6	14	BOS	6	22	BOS	6	36
TOTAL	28	146	TOTAL	38	198	TOTAL	58	300

	FLEET OF 26 C - 130 TOTAL FOR 26 OFFICER	ENLISTED		FLEET OF 26 C - 130 AVERAGE PER AIRCRAFT OFFICER	ENLISTED
CREW	52	130	CREW	2.00	5.00
OTHER	54	442	OTHER	2.08	17.00
BOS	18	72	BOS	0.69	2.77
TOTAL	124	644	TOTAL	4.77	24.77

APPENDIX B - 4

COMPUTATION OF STAFFING FOR HU - 25

SINGLE BASE INPUTS PAGE 1

Coast	HU - 25			Coast	HU - 25			Coast	HU - 25	
Guard	2 PER STATION			Guard	3 PER STATION			Guard	6 PER STATION	
Input	OFF	ENL		Input	OFF	ENL		Input	OFF	ENL
CREW	4	6		CREW	6	9		CREW	12	18
OTHER	4	22		OTHER	4	24		OTHER	10	48
BOS	5	13		BOS	3	8		BOS	3	5
TOTAL	13	41		TOTAL	13	41		TOTAL	25	71
NUMBER OF				NUMBER OF				NUMBER OF		
BASES				BASES				BASES		
1				2				1		
	TOTAL				TOTAL				TOTAL	
	HU - 25				HU - 25				HU - 25	
	2 PER STATION				3 PER STATION				6 PER STATION	
	OFF	ENL			OFF	ENL			OFF	ENL
CREW	4	6		CREW	12	18		CREW	12	18
OTHER	4	22		OTHER	8	48		OTHER	10	48
BOS	5	13		BOS	6	16		BOS	3	5
TOTAL	13	41		TOTAL	26	82		TOTAL	25	71

SINGLE BASE INPUTS						
	HU - 25				HU - 25	
	8 PER STATION				10 PER STATION	
	OFF	ENL			OFF	ENL
CREW	16	24		CREW	20	30
OTHER	14	64		OTHER	18	80
BOS	3	5		BOS	3	8
TOTAL	33	93		TOTAL	41	118
NUMBER OF				NUMBER OF		
BASES				BASES		
1				1		
	TOTAL				TOTAL	
	HU - 25				HU - 25	
	8 PER STATION				10 PER STATION	
	OFF	ENL			OFF	ENL
CREW	16	24		CREW	20	30
OTHER	14	64		OTHER	18	80
BOS	3	5		BOS	3	8
TOTAL	33	93		TOTAL	41	118

FLEET TOTALS								
	FLEET OF 32				FLEET OF 32			
	HU - 25				HU - 25			
	TOTAL FOR 32				AVERAGE PER AIRCRAFT			
	OFF	ENL			OFF	ENL		
CREW	64	96		CREW	2.00	3.00		
OTHER	54	262		OTHER	1.69	8.19		
BOS	20	47		BOS	0.63	1.47		
TOTAL	138	405		TOTAL	4.31	12.66		

APPENDIX B - 4										
COMPUTATION OF STAFFING FOR HH - 65 A										
SINGLE BASE INPUTS										
Coast	HH-65 A			Coast	HH-65 A			Coast	HH-65 A	
Guard	2 PER STATION			Guard	3 PER STATION			Guard	4 PER STATION	
Input	OFF	ENL		Input	OFF	ENL		Input	OFF	ENL
CREW	4	2		CREW	6	3		CREW	8	4
OTHER	4	20		OTHER	6	30		OTHER	8	40
BOS	5	13		BOS	3	6		BOS	2	1
TOTAL	13	35		TOTAL	15	39		TOTAL	18	45
NUMBER OF				NUMBER OF				NUMBER OF		
BASES				BASES				BASES		
1				8				4		
	TOTAL				TOTAL				TOTAL	
	HH-65 A				HH-65 A				HH-65 A	
	2 PER STATION				3 PER STATION				4 PER STATION	
	OFF	ENL			OFF	ENL			OFF	ENL
CREW	4	2		CREW	48	24		CREW	32	16
OTHER	4	20		OTHER	48	240		OTHER	32	160
BOS	5	13		BOS	24	48		BOS	8	4
TOTAL	13	35		TOTAL	120	312		TOTAL	72	180

APPENDIX B - 4

COMPUTATION OF STAFFING FOR HH - 65 A

SINGLE BASE INPUTS

Coast	HH-65 A			Coast	HH-65 A	
Guard	5 PER STATION			Guard	6 PER STATION	
Input	OFF	ENL		Input	OFF	ENL
CREW	10	5		CREW	12	6
OTHER	10	50		OTHER	12	60
BOS	3	1		BOS	4	1
TOTAL	23	56		TOTAL	28	67

NUMBER OF				NUMBER OF		
BASES				BASES		
3				1		

	TOTAL				TOTAL	
	HH-65 A				HH-65 A	
	5 PER STATION				6 PER STATION	
	OFF	ENL			OFF	ENL
CREW	30	15		CREW	12	6
OTHER	30	150		OTHER	12	60
BOS	9	3		BOS	4	1
TOTAL	69	168		TOTAL	28	67

APPENDIX B - 4						
COMPUTATION OF STAFFING FOR HH - 65 A						
SINGLE BASE INPUTS						
	HH-65 A				HH-65 A	
	8 PER STATION				9 PER STATION	
	OFF	ENL			OFF	ENL
CREW	16	8		CREW	18	9
OTHER	16	80		OTHER	18	90
BOS	4	1		BOS	5	1
TOTAL	36	89		TOTAL	41	100
NUMBER OF				NUMBER OF		
BASES				BASES		
1				1		
	HH-65 A				HH-65 A	
	8 PER STATION				9 PER STATION	
	OFF	ENL			OFF	ENL
CREW	16	8		CREW	18	9
OTHER	16	80		OTHER	18	90
BOS	4	1		BOS	5	1
TOTAL	36	89		TOTAL	41	100

APPENDIX B - 4

COMPUTATION OF STAFFING FOR HH - 65 A

FLEET TOTALS

	FLEET OF 80			FLEET OF 80		
	HH-65 A			HH-65 A		
	TOTAL FOR 80			AVERAGE PER AIRCRAFT		
	OFF	ENL		OFF	ENL	
CREW	160	80	CREW	2.00	1.00	
OTHER	160	800	OTHER	2.00	10.00	
BOS	59	71	BOS	0.74	0.89	
TOTAL	379	951	TOTAL	4.74	11.89	